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updated as appropriate

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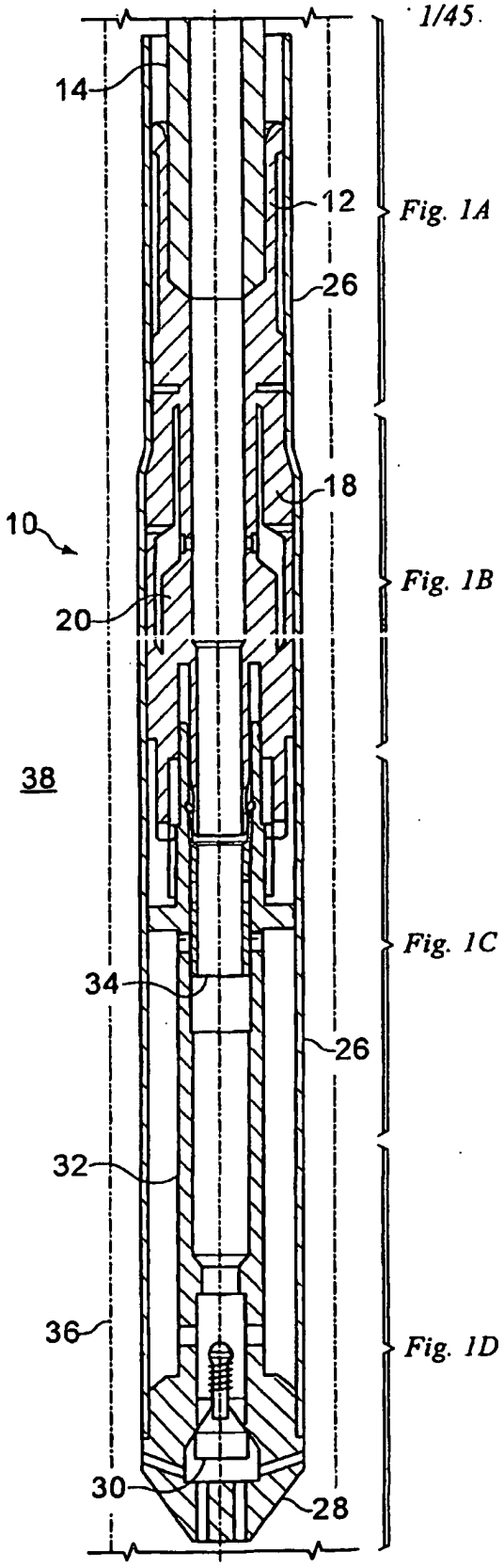

Fig. 1

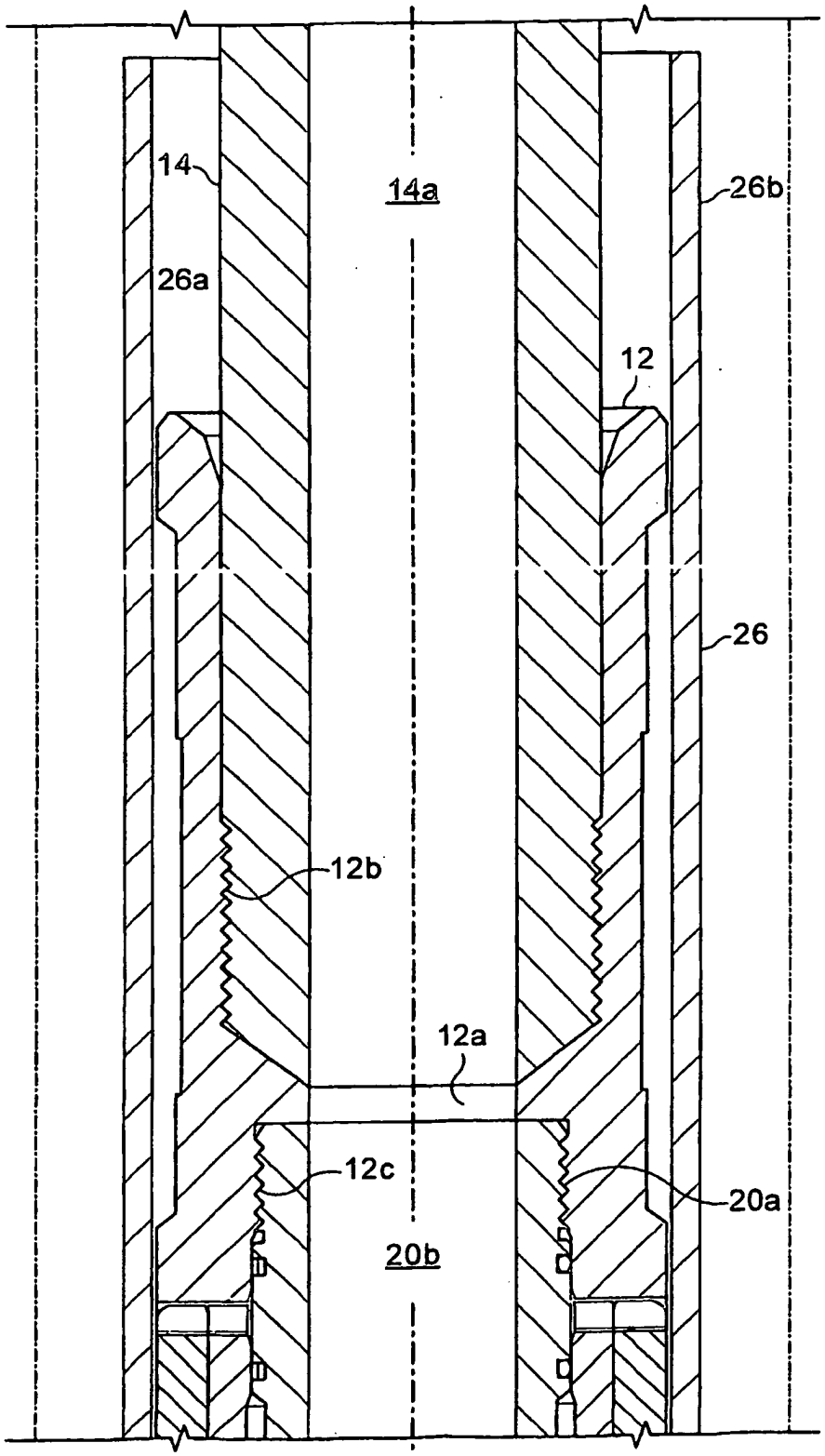

Fig. 1A

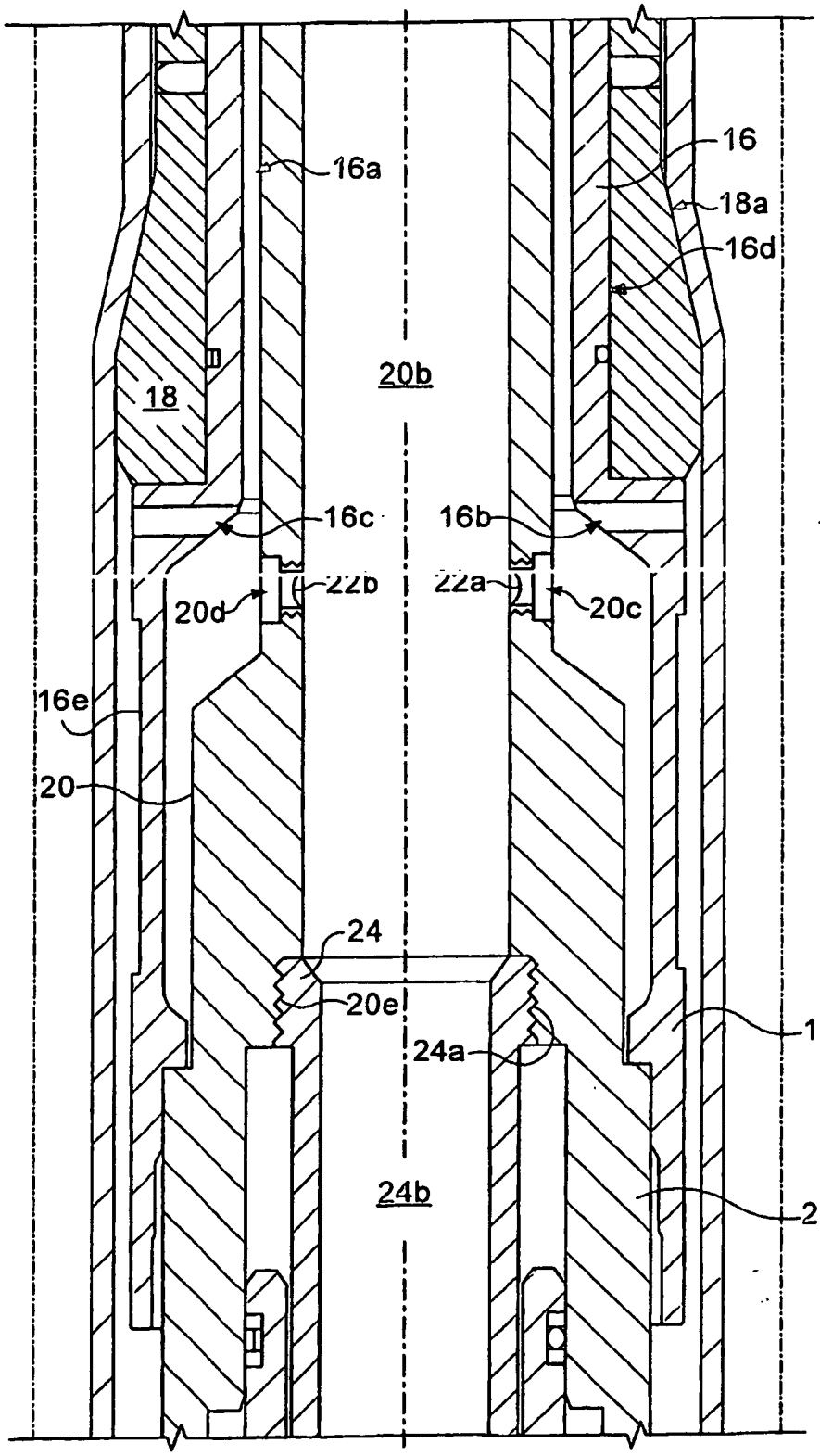
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Fig. 1B

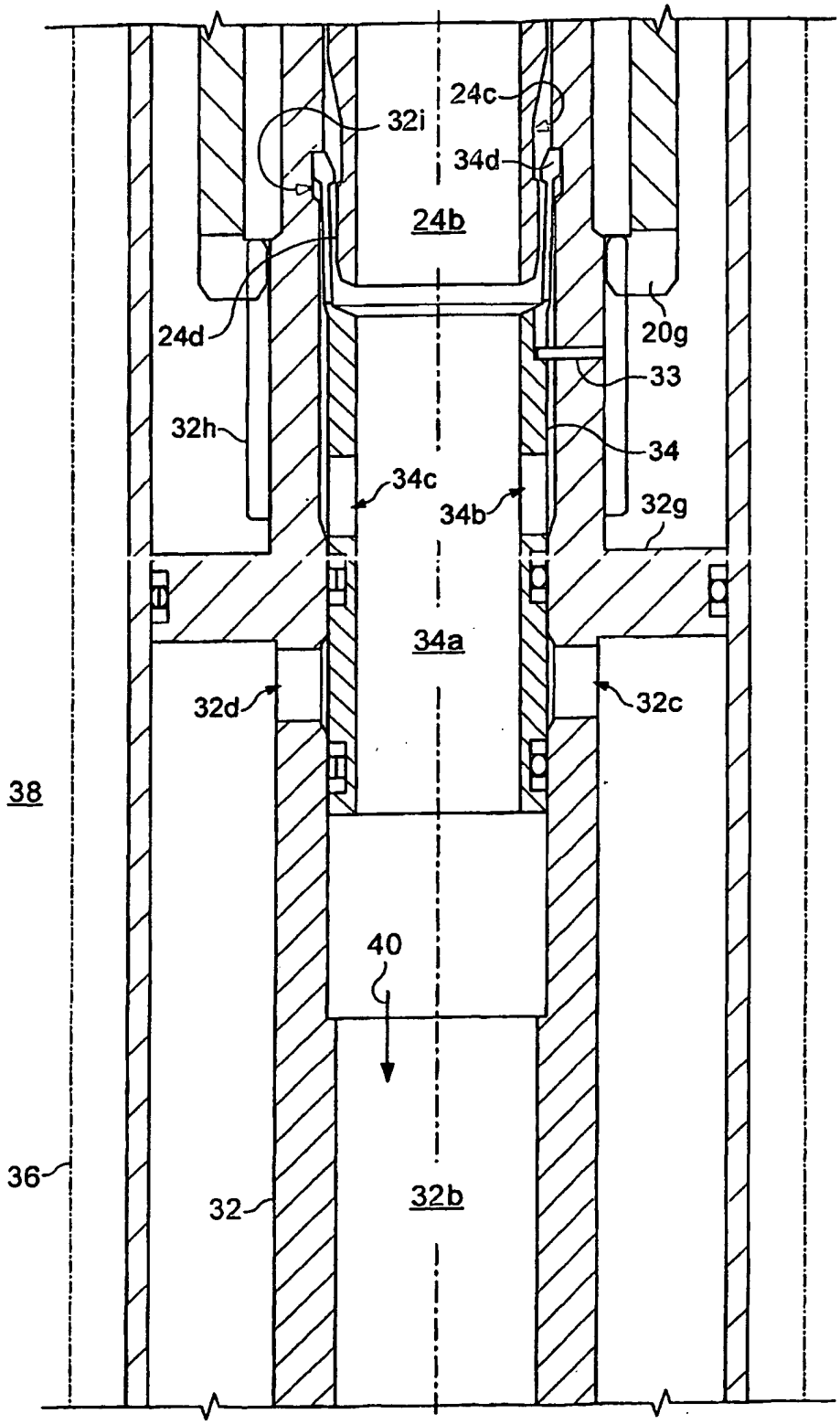
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Fig. 1C

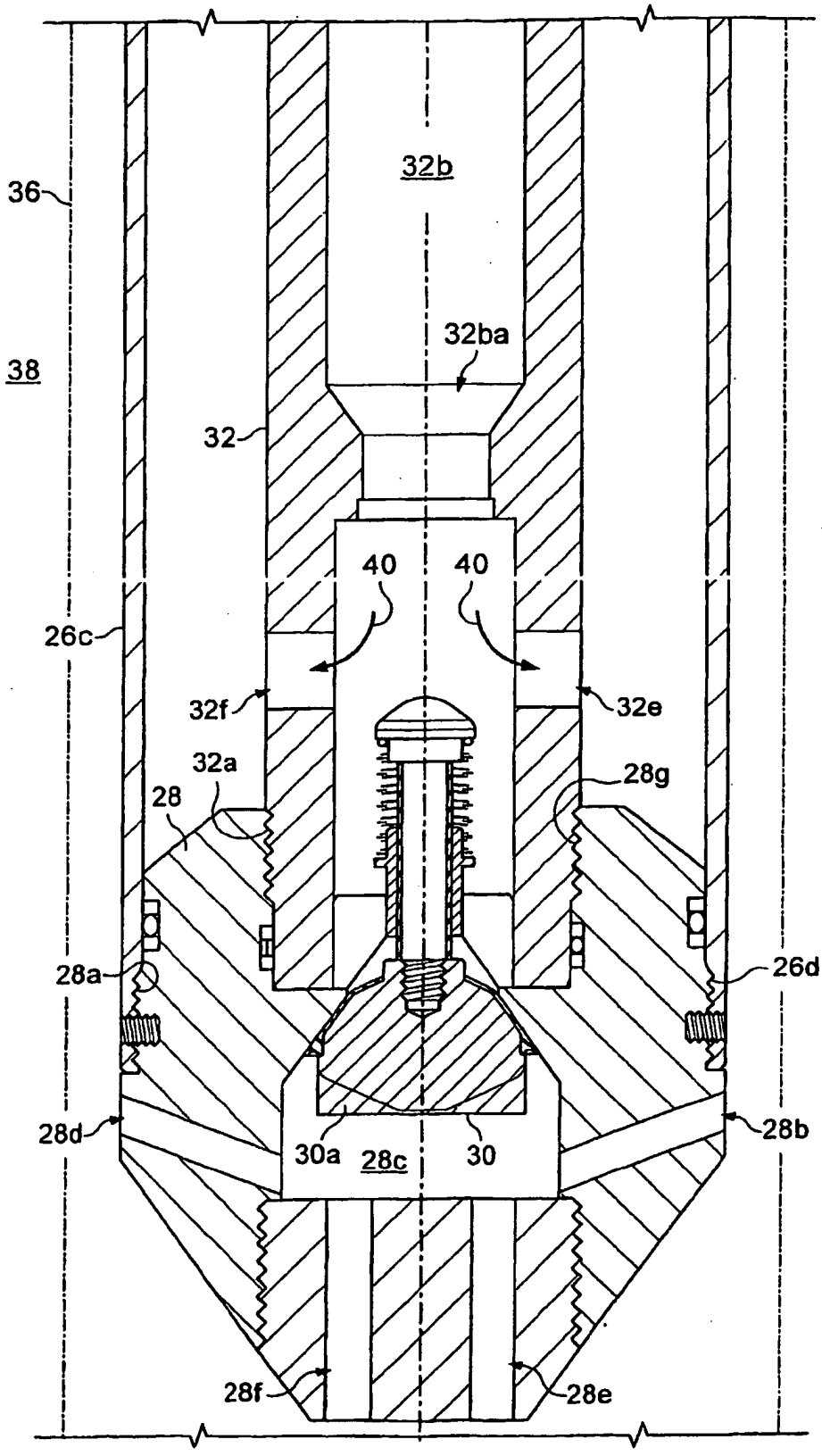
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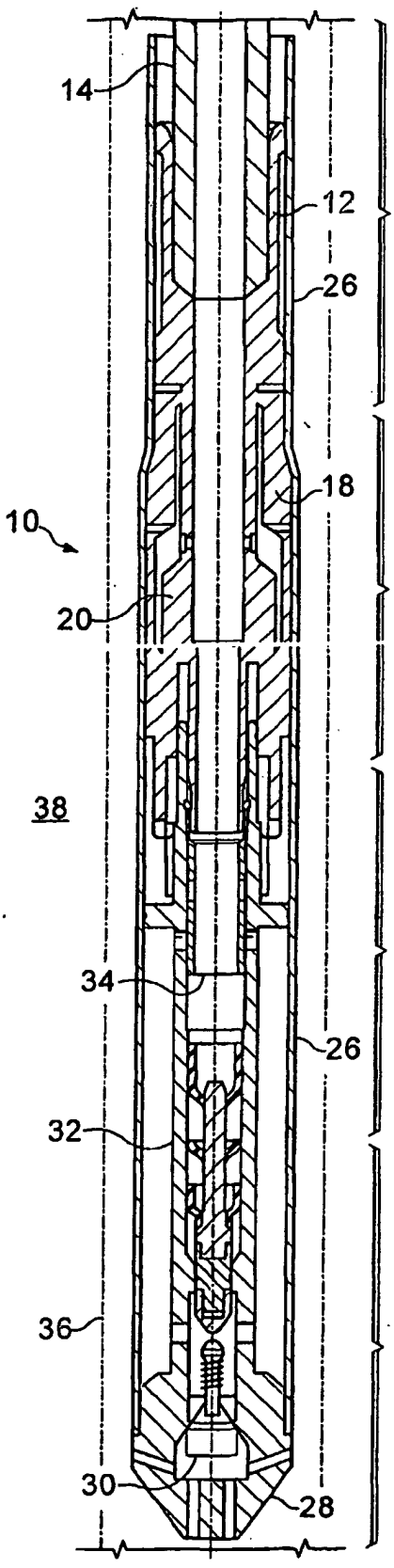
Fig. 1D



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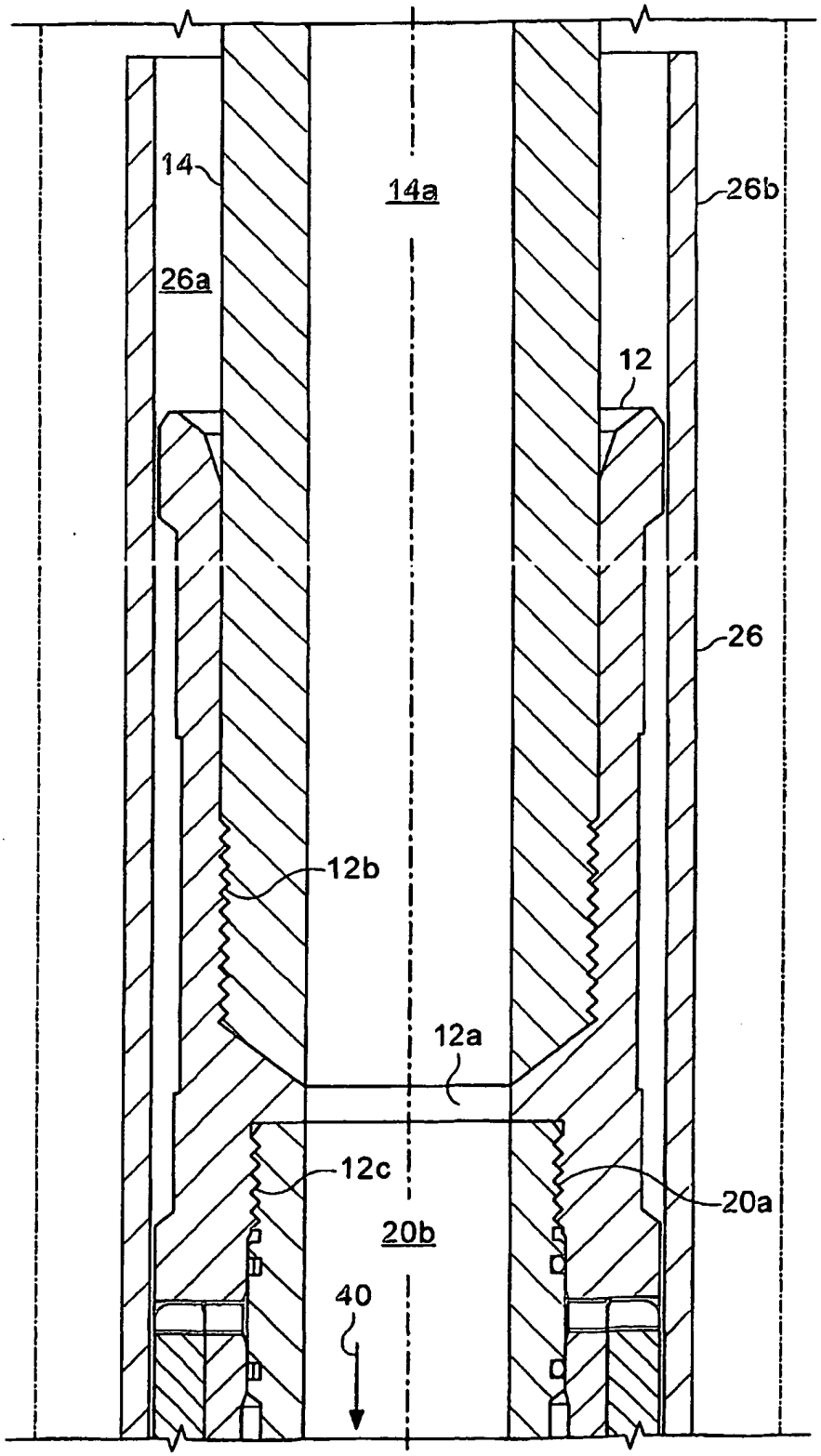

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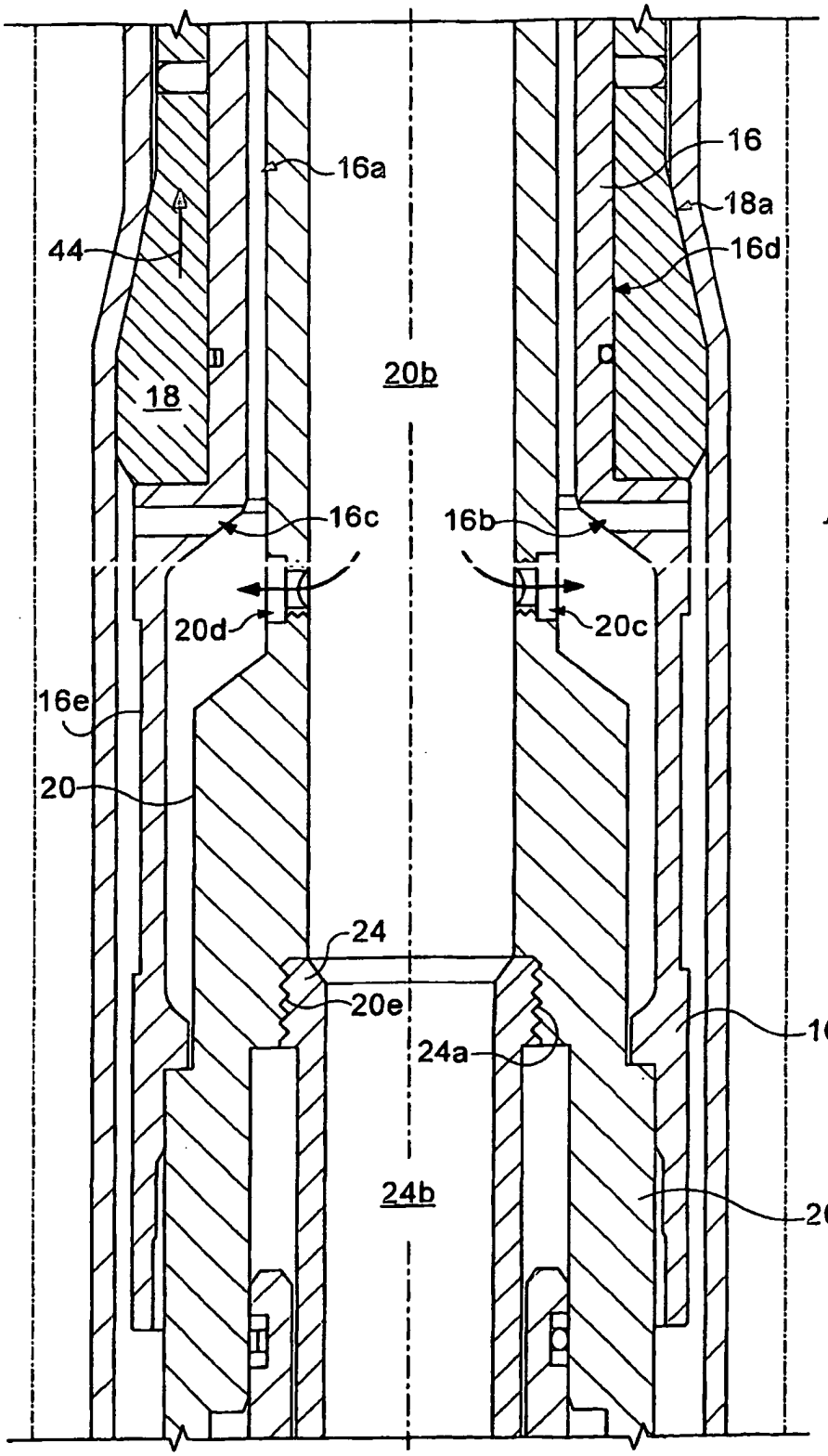
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Fig. 2B

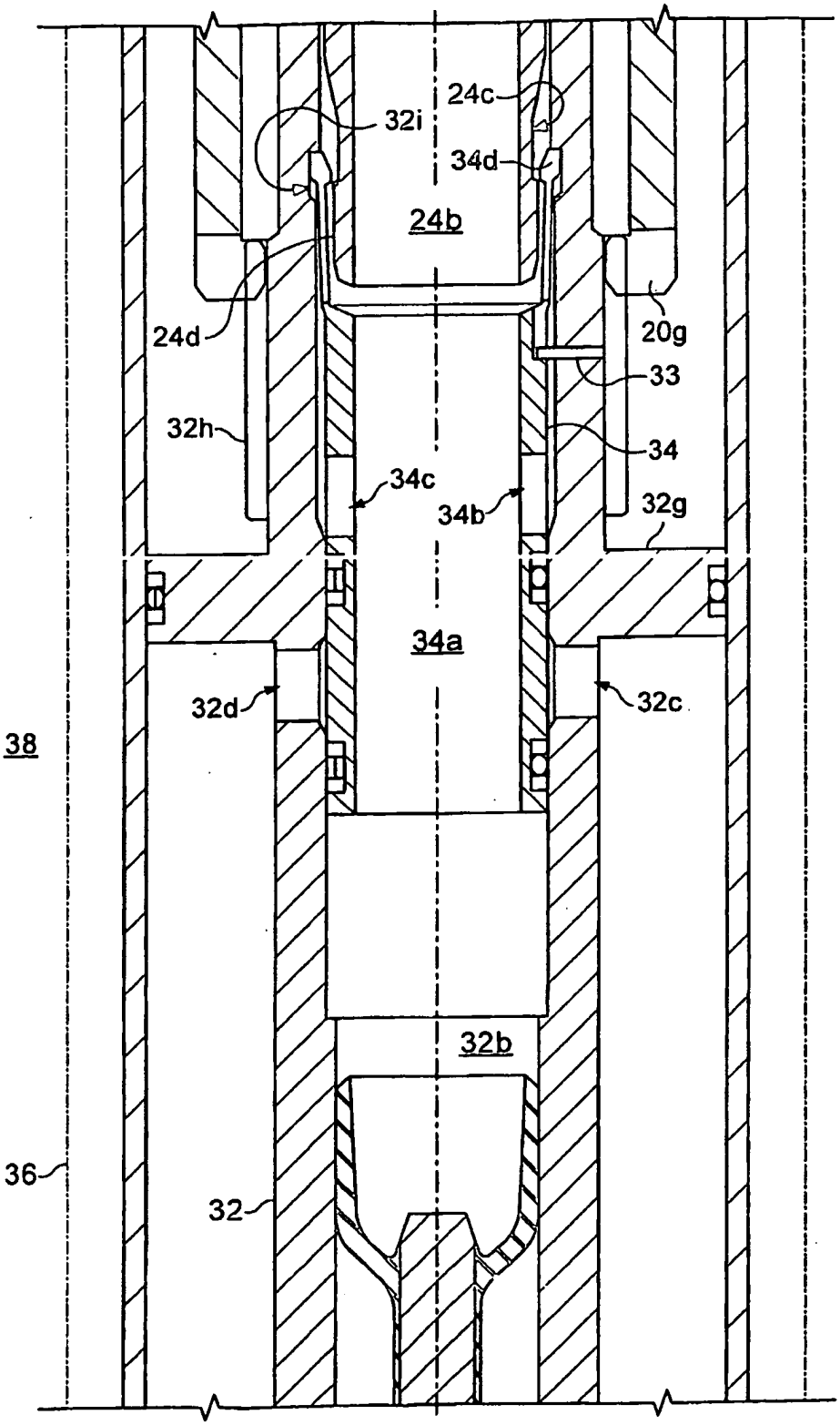
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Fig. 2C

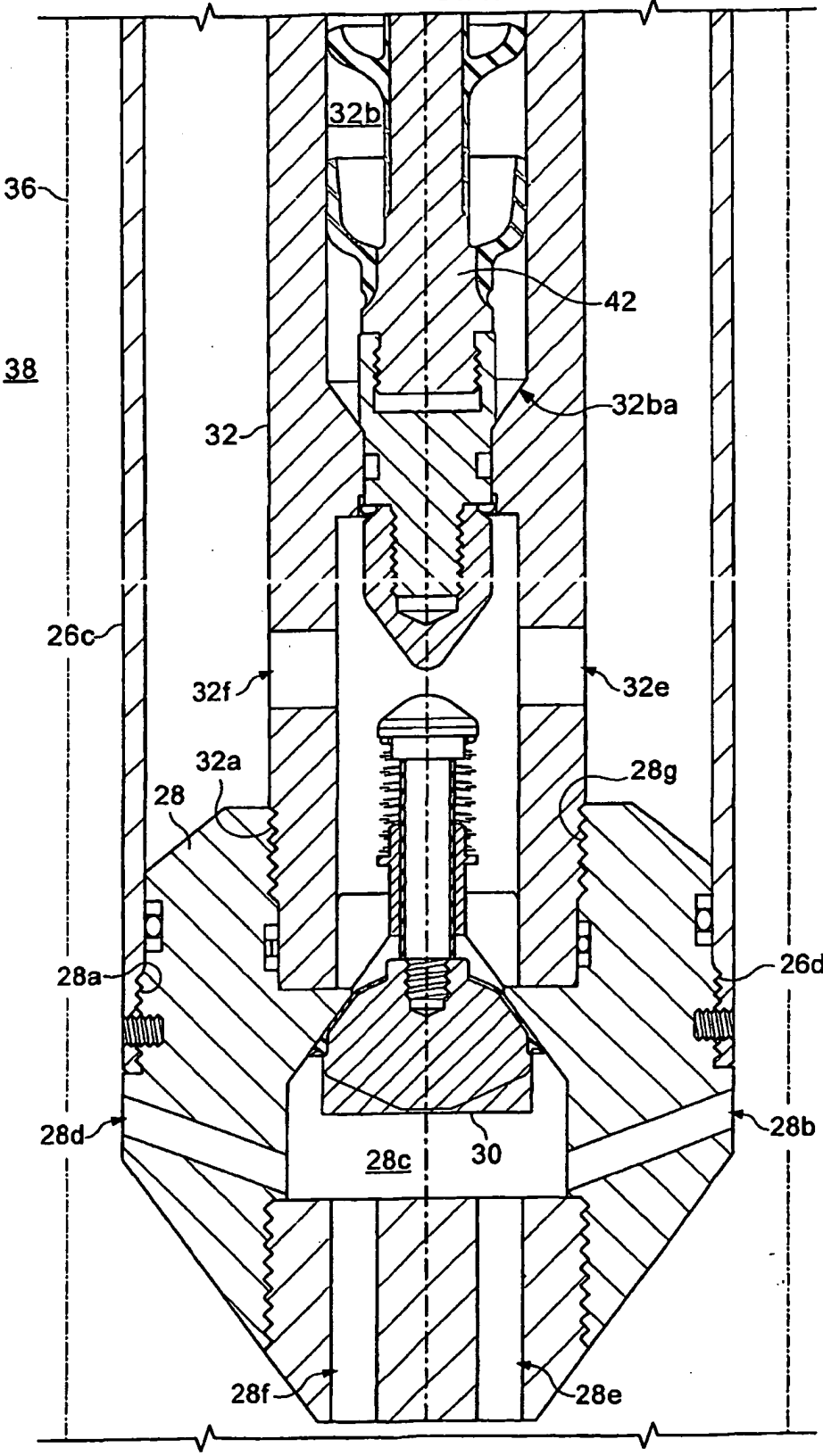
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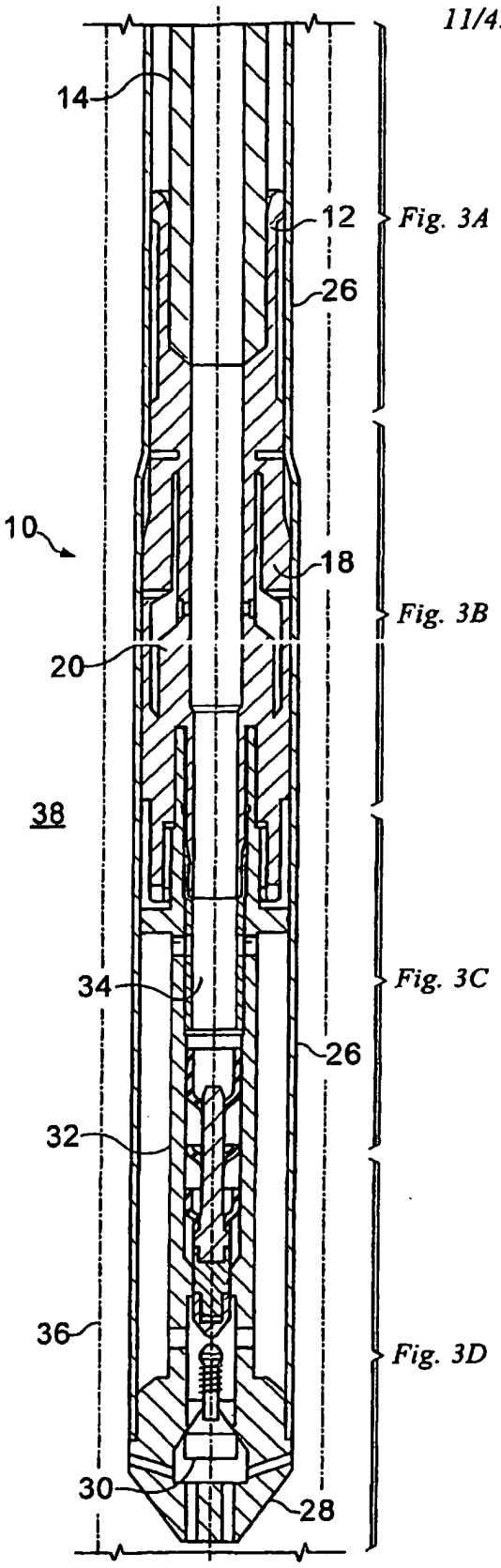
Fig. 2D



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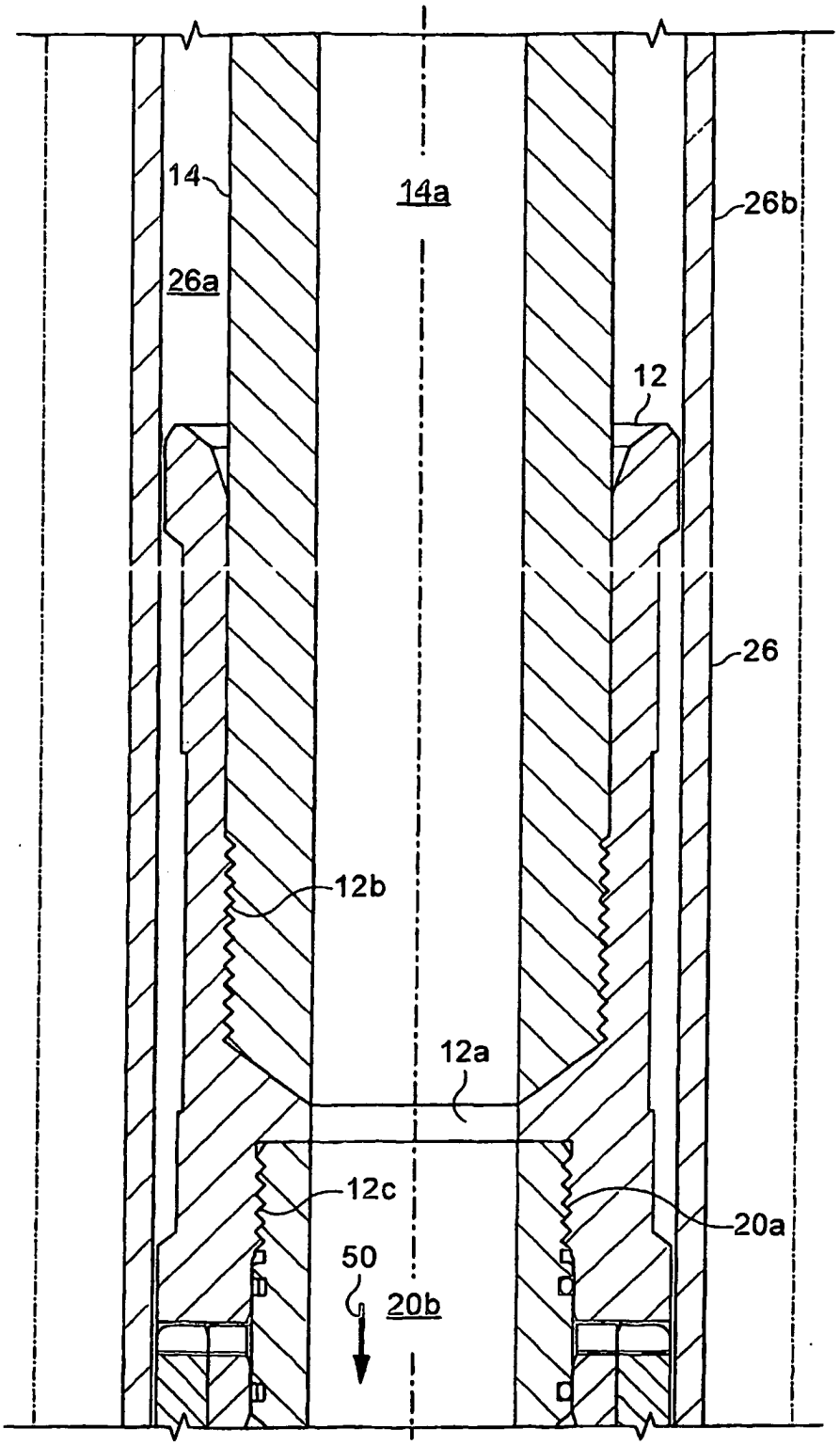

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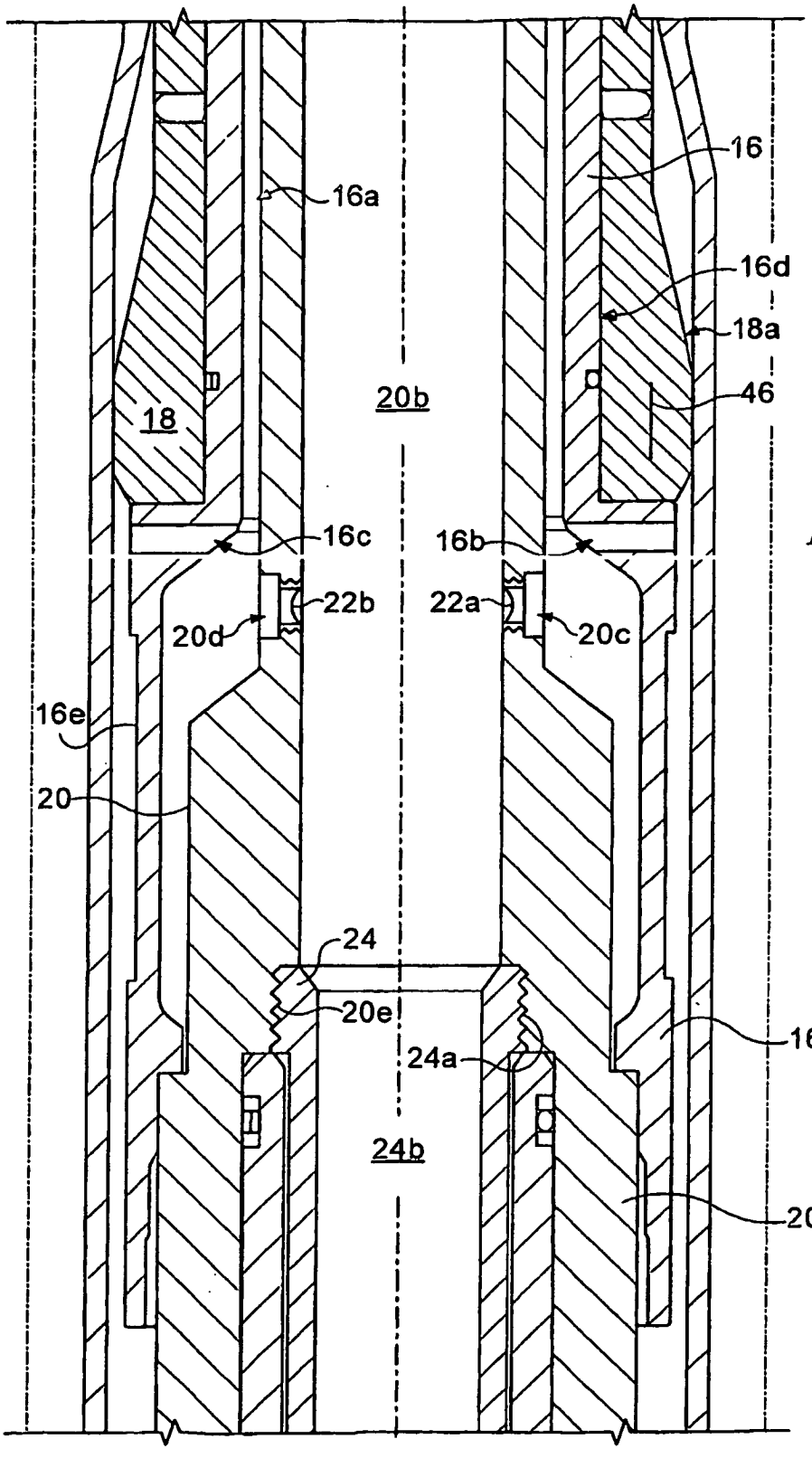
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Fig. 3B

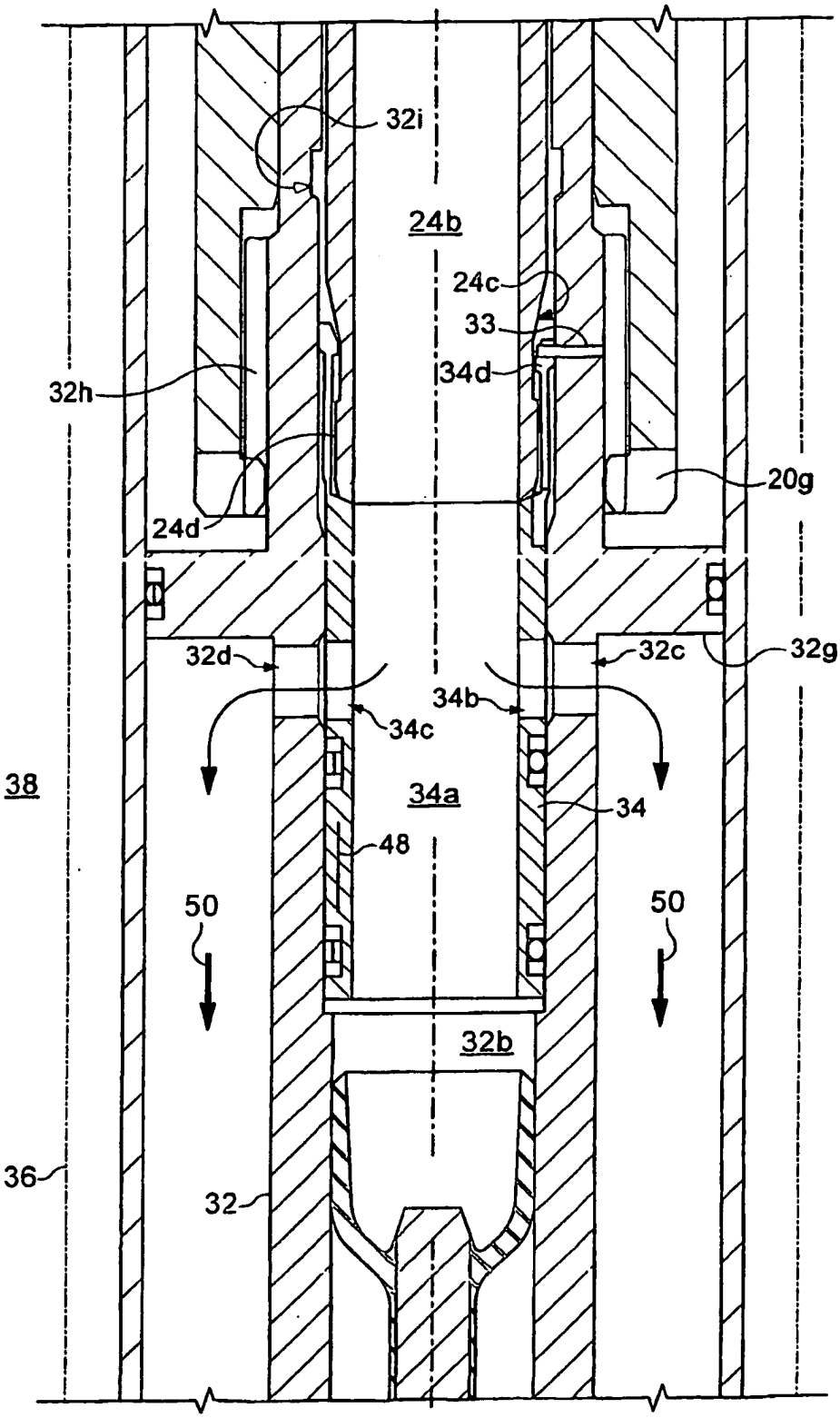
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Fig. 3C

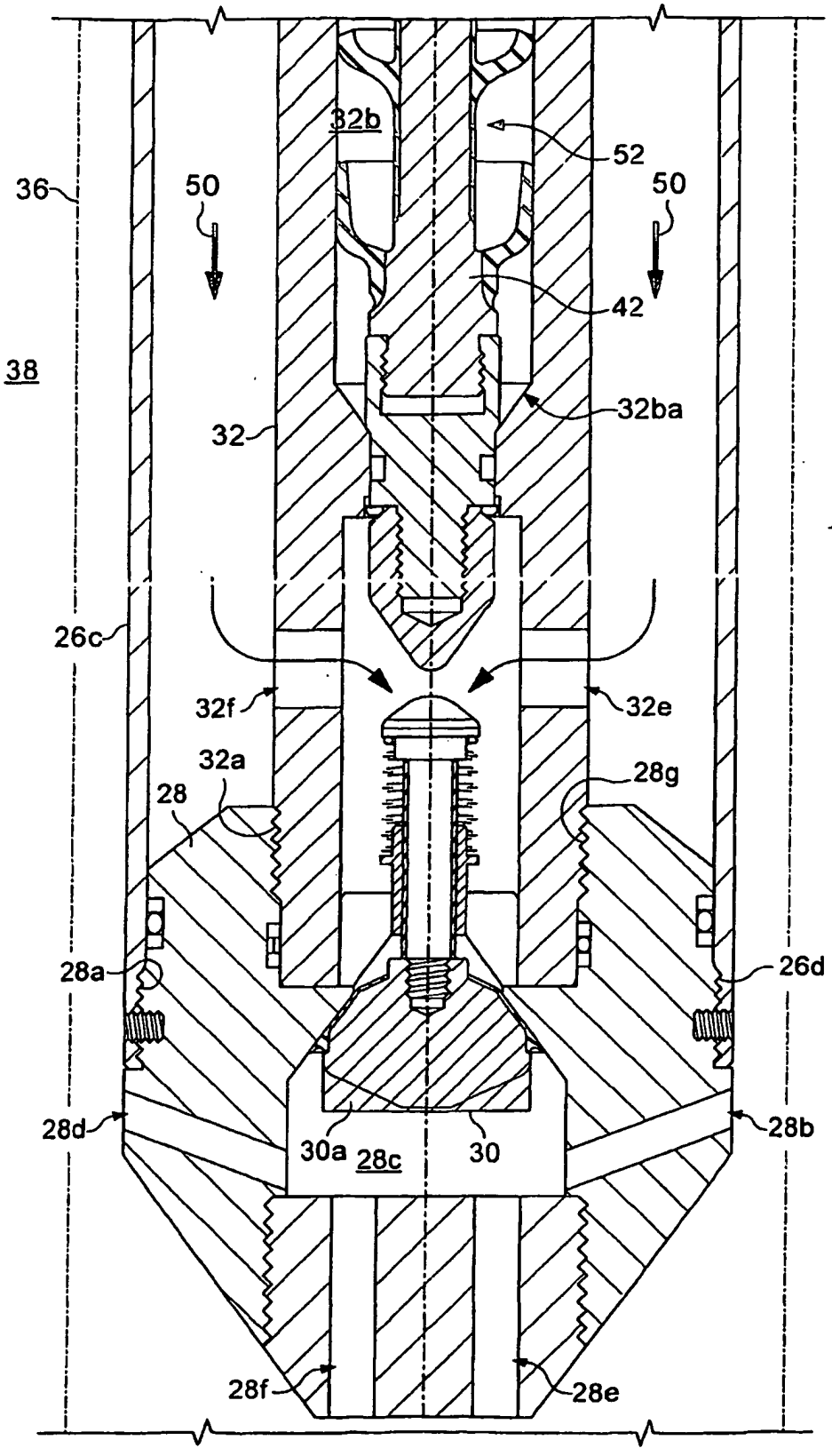
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Fig. 3D

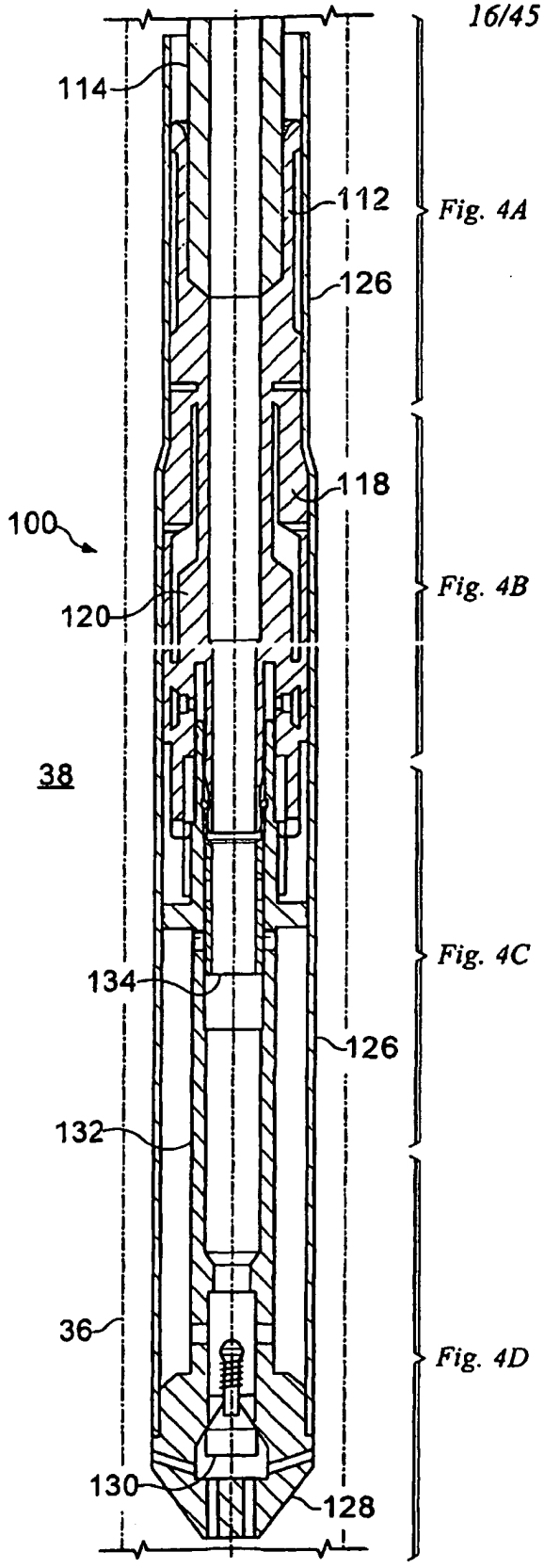
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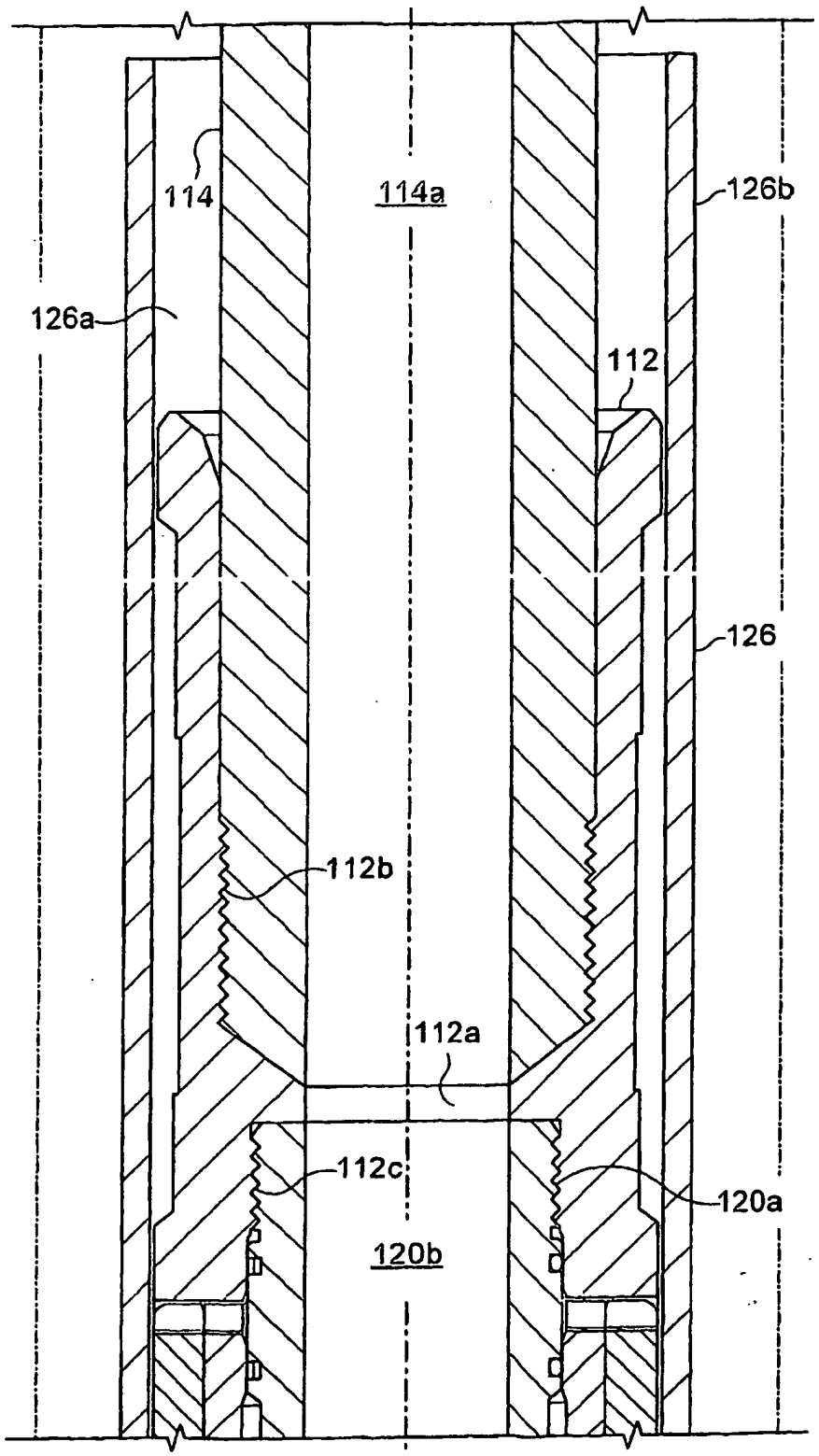
Fig. 4A
Fig. 4B
Fig. 4C
Fig. 4D

Fig. 4



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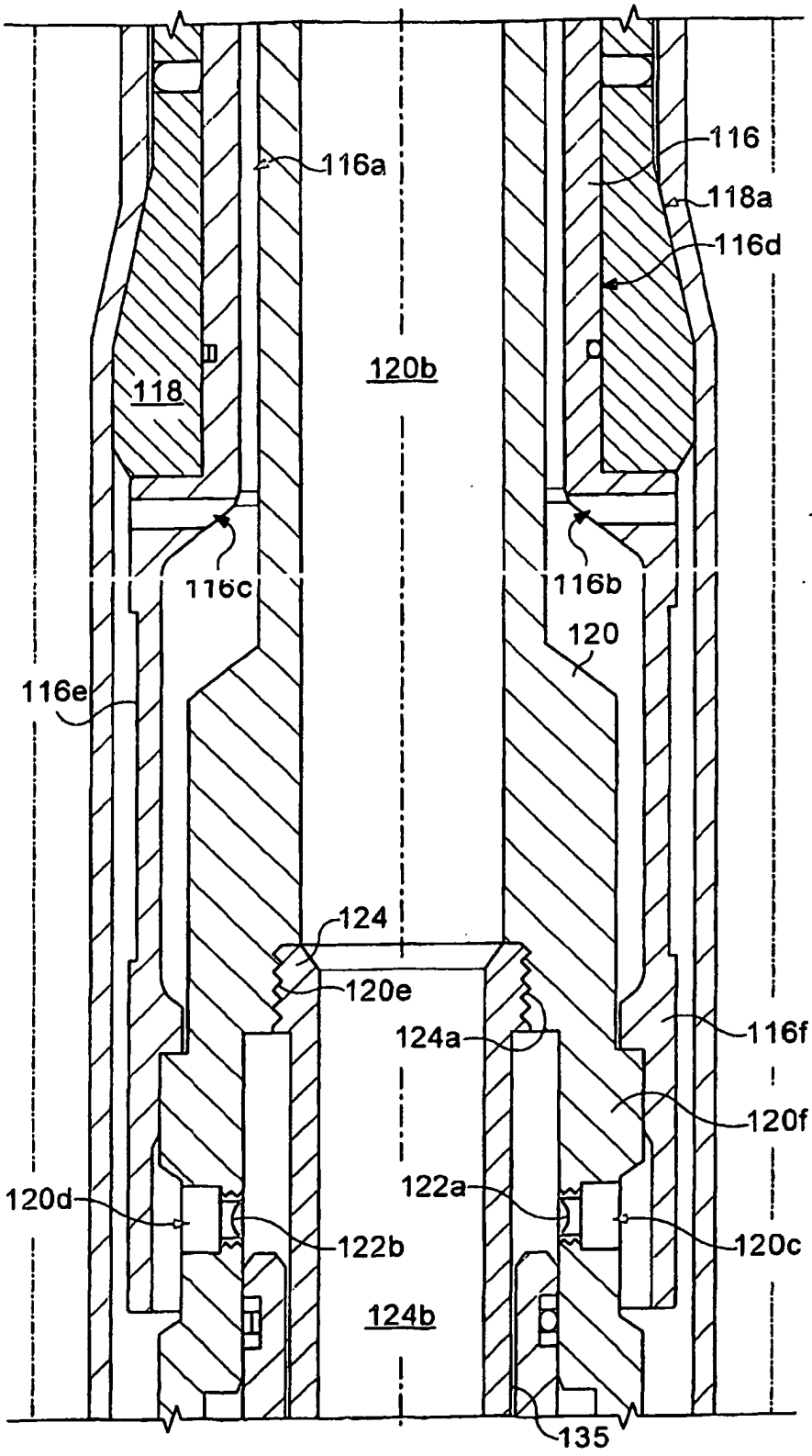
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Fig. 4B

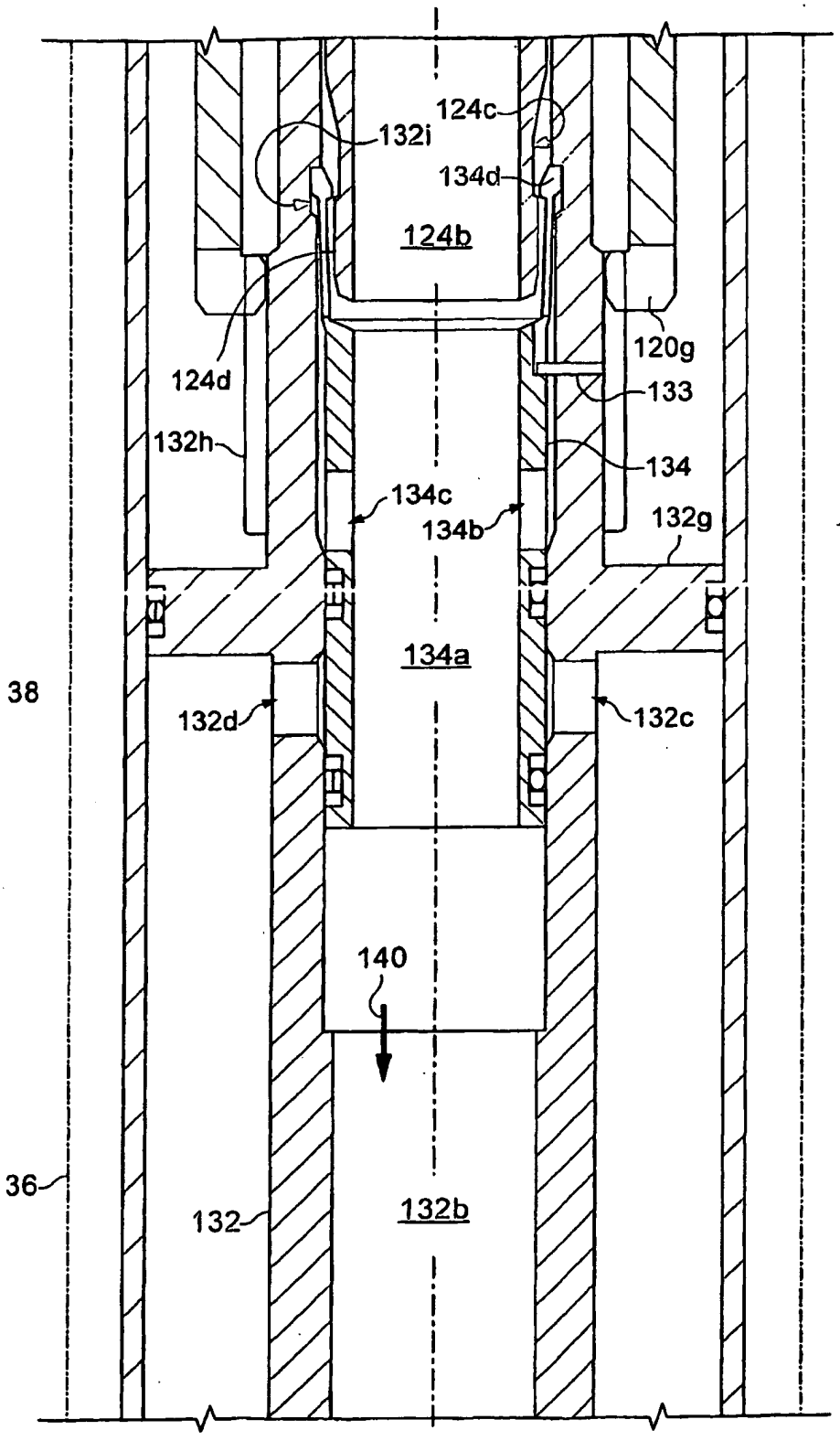
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Fig. 4C

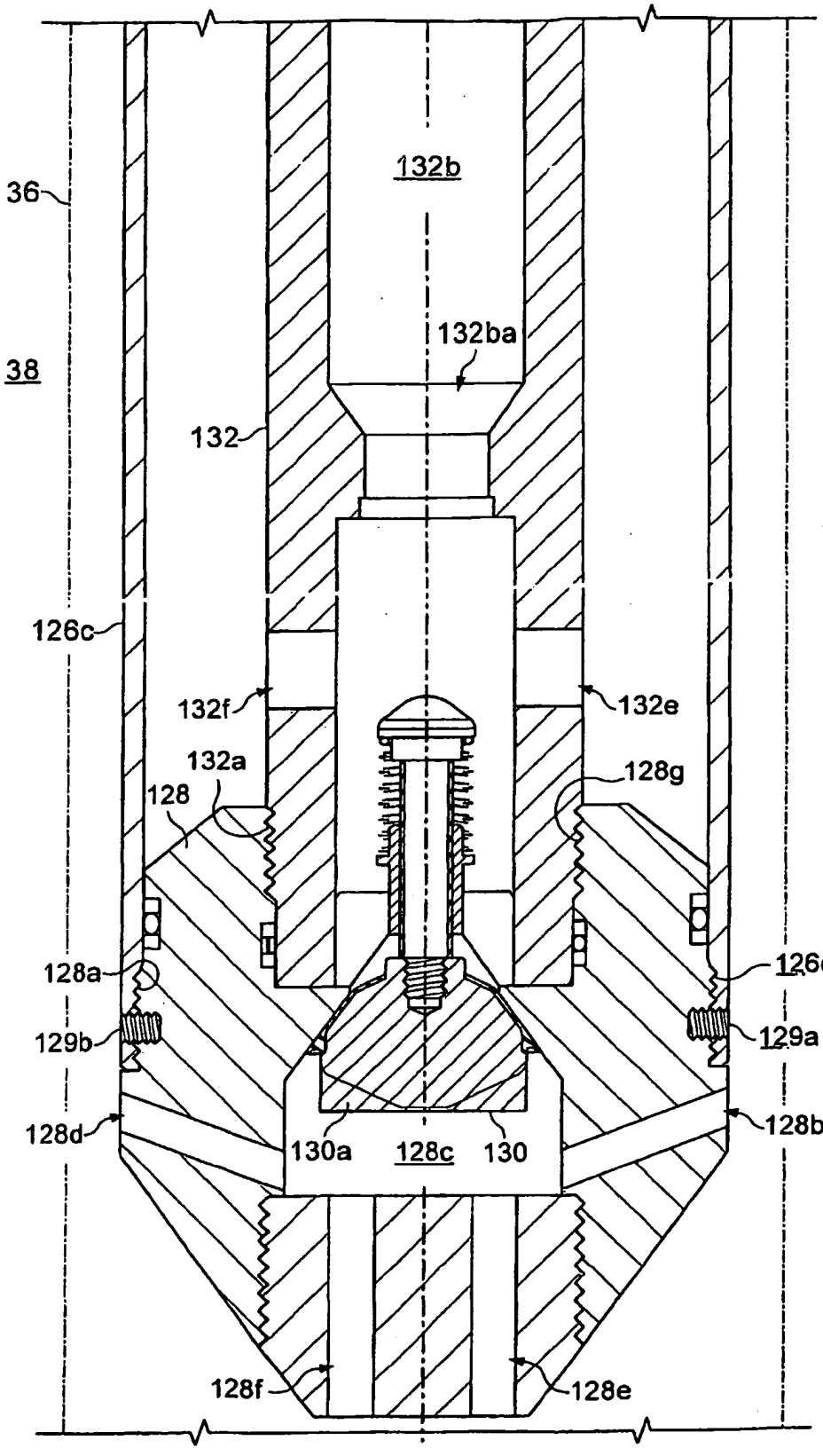
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Fig. 4D

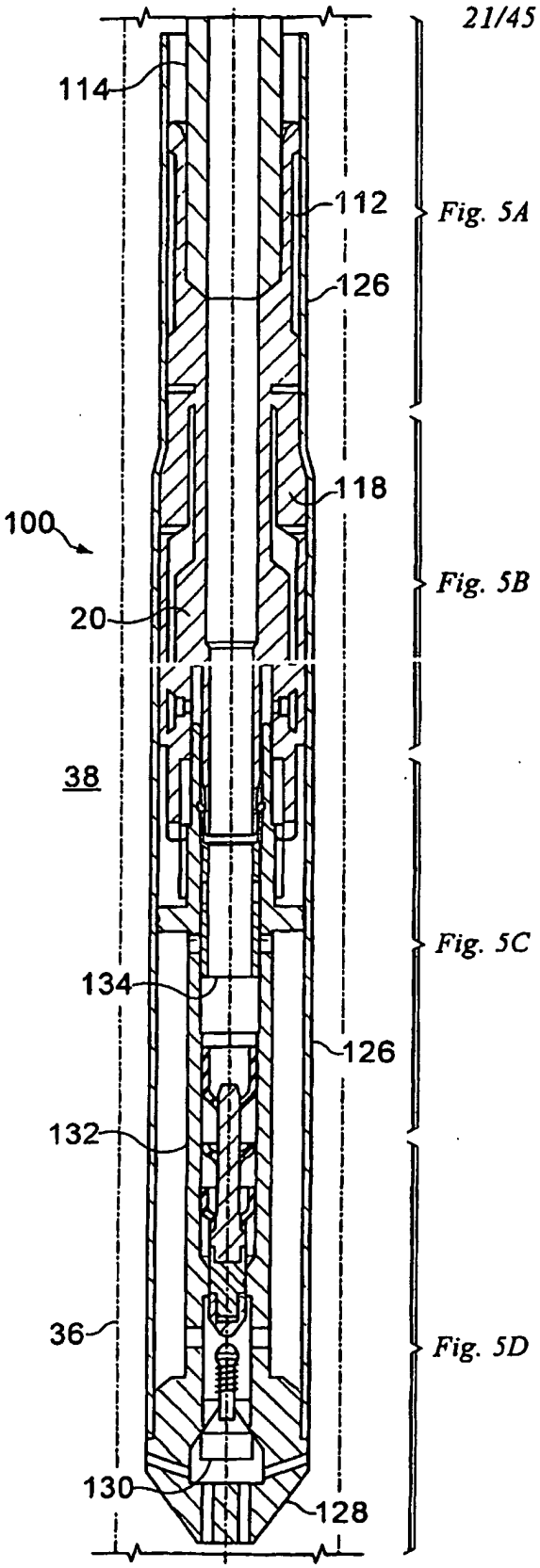
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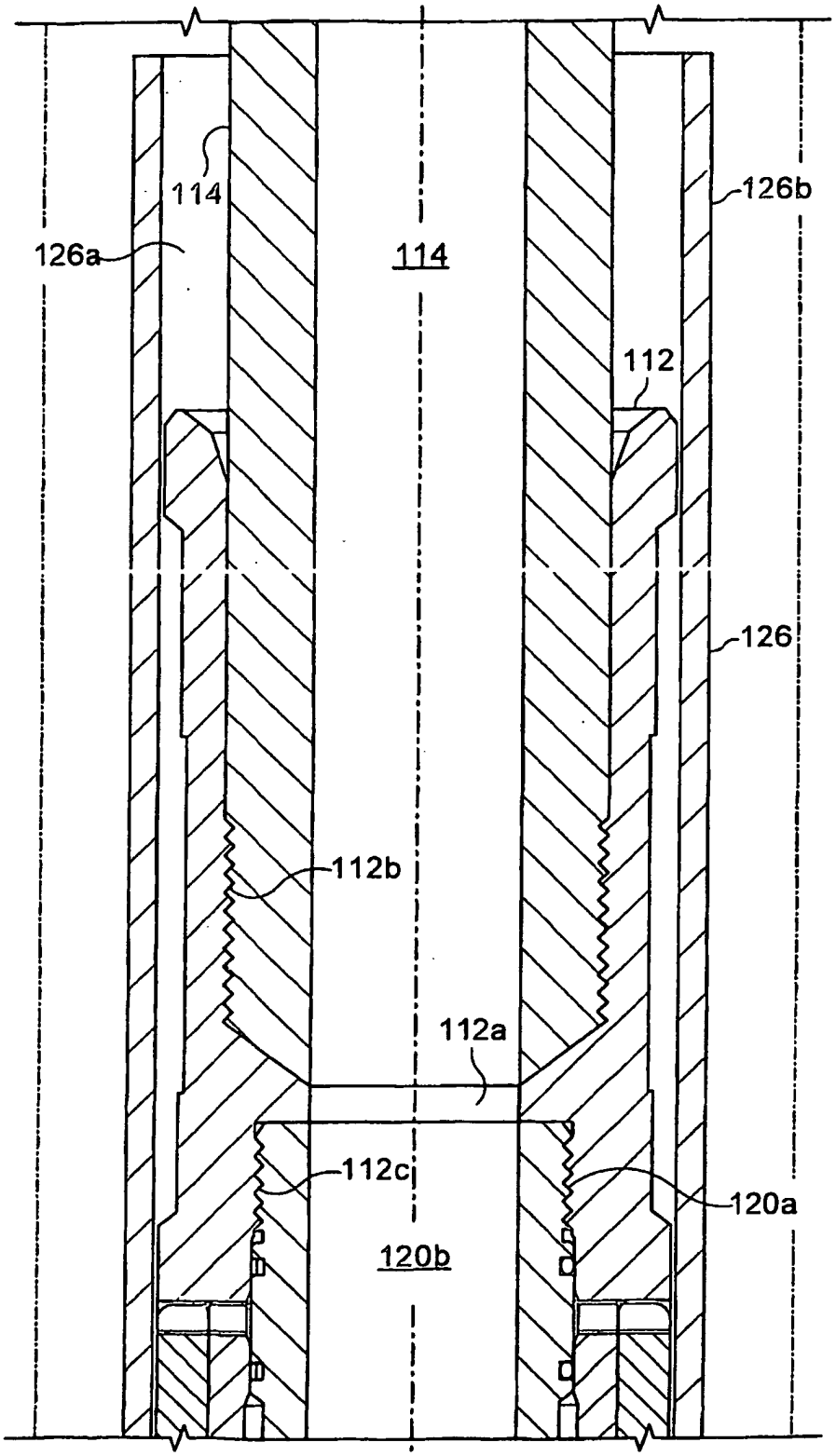
Fig. 5A
Fig. 5B
Fig. 5C
Fig. 5D

Fig. 5



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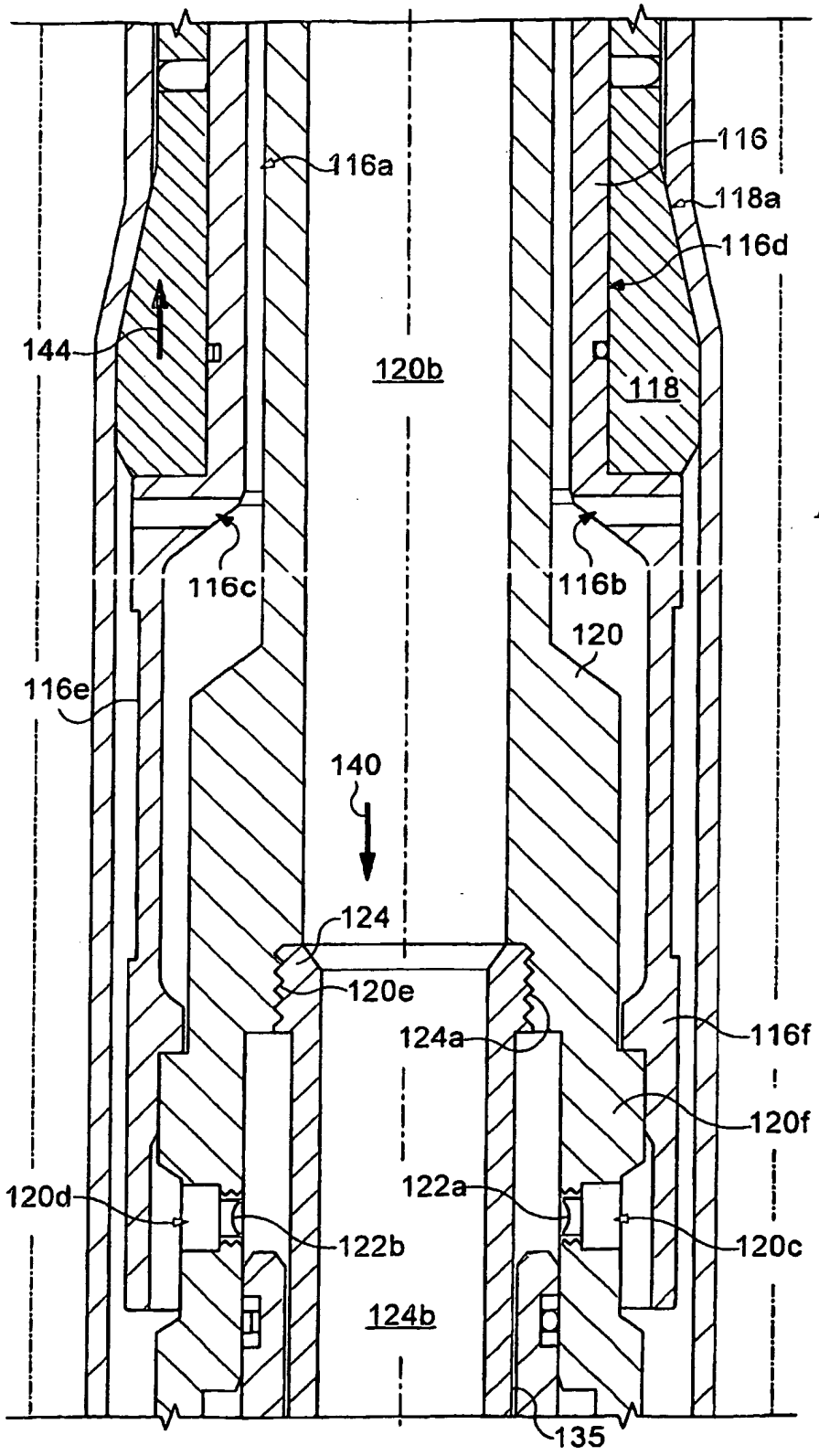
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Fig. 5B

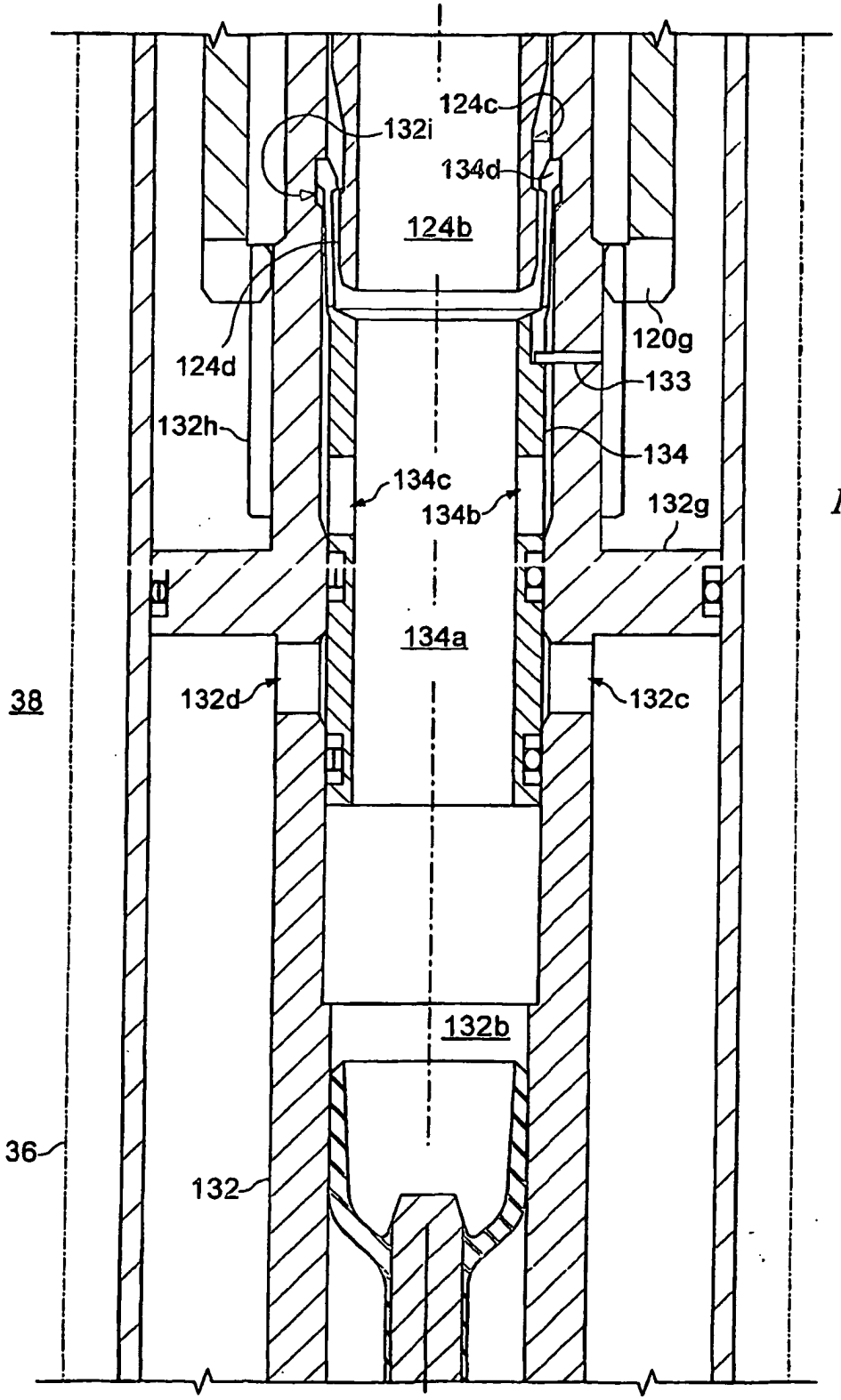
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Fig. 5C

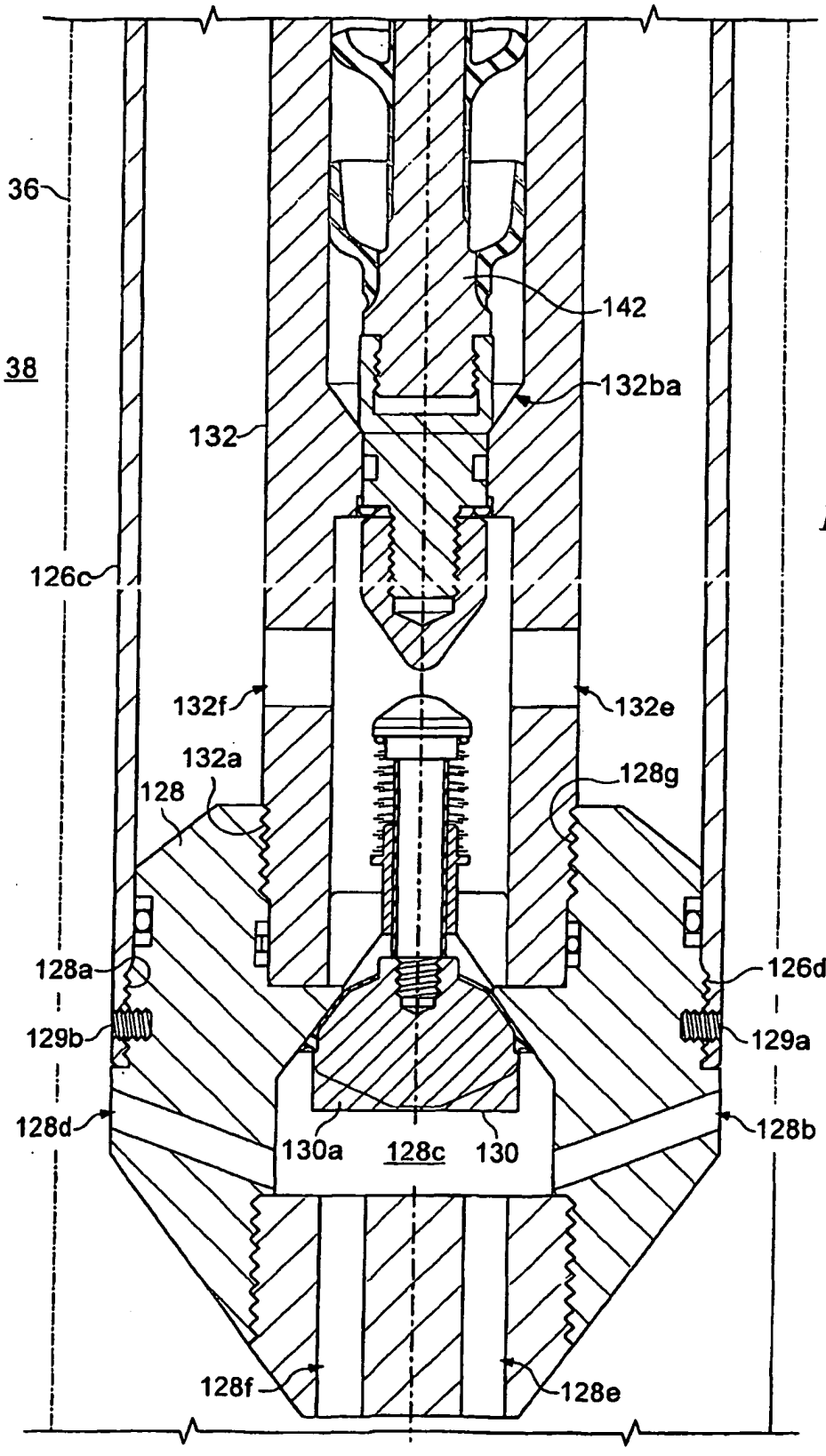
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Fig. 5D

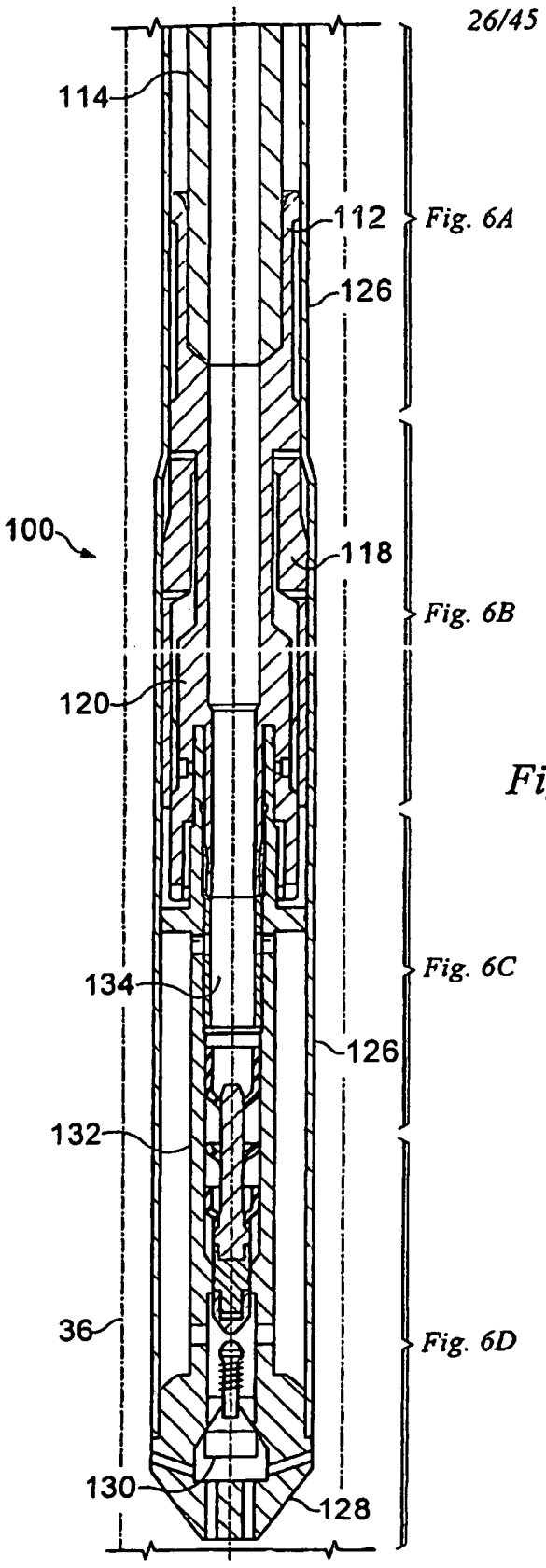
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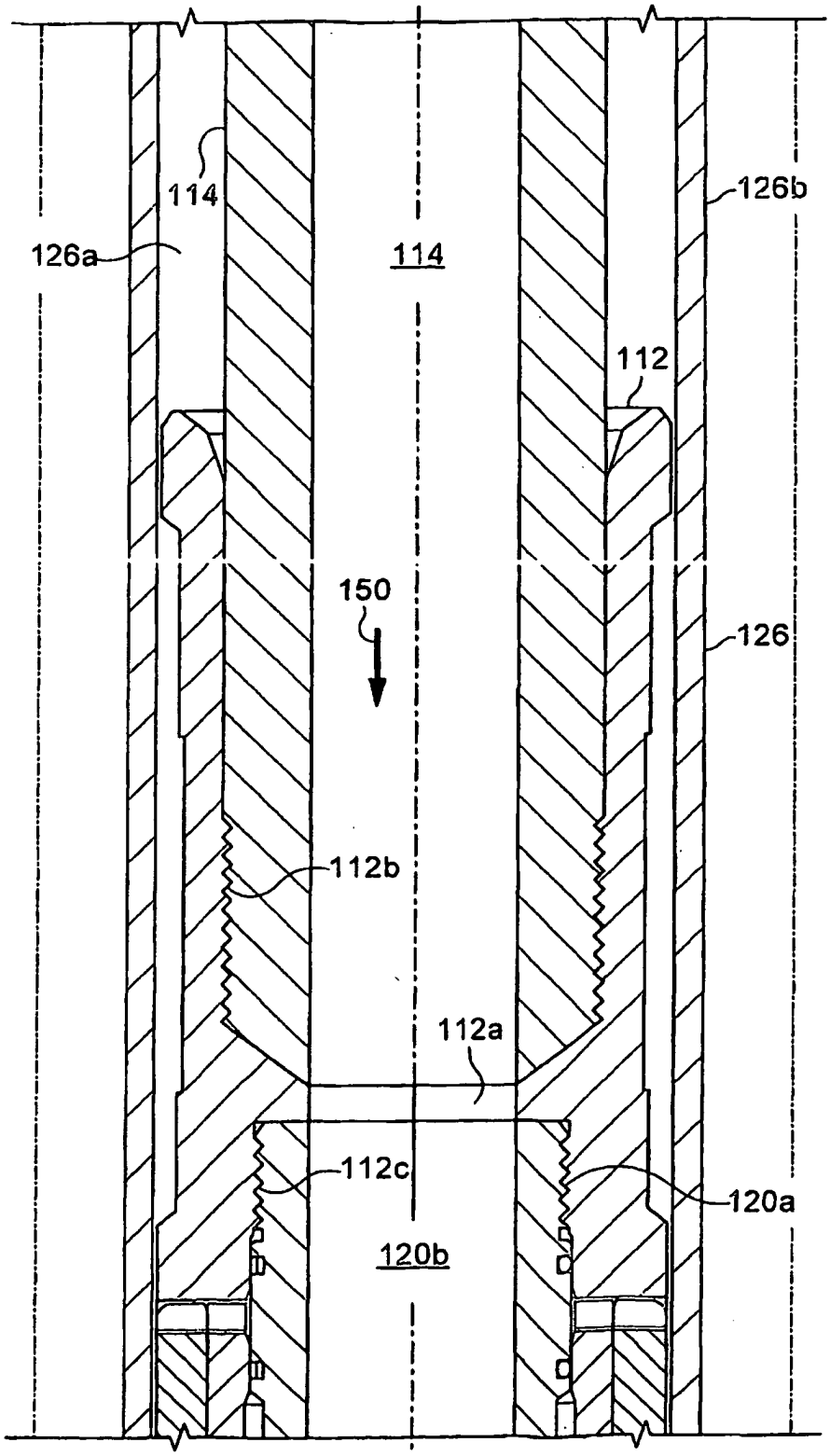
Fig. 6A
Fig. 6B
Fig. 6C
Fig. 6D

Fig. 6



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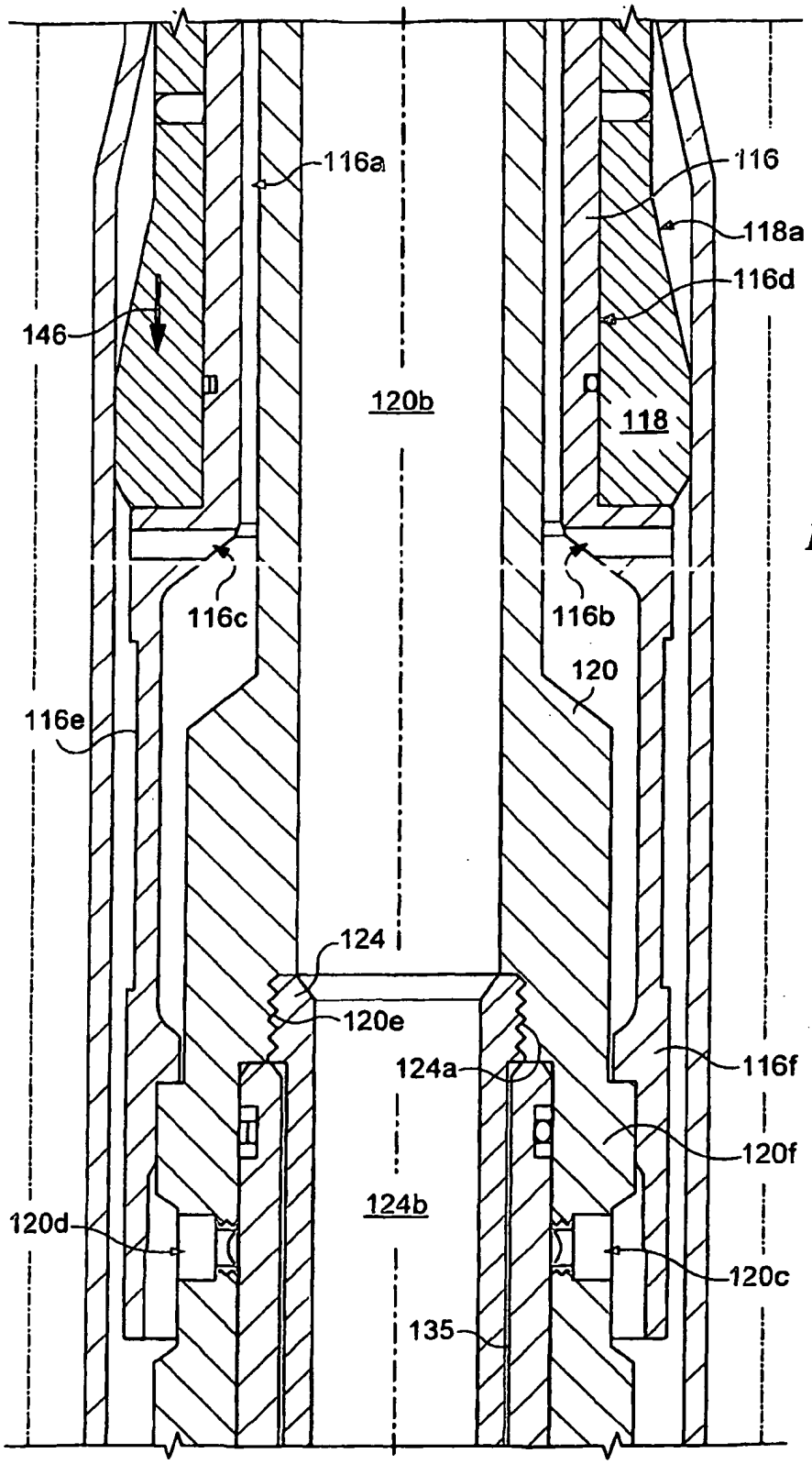
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Fig. 6B

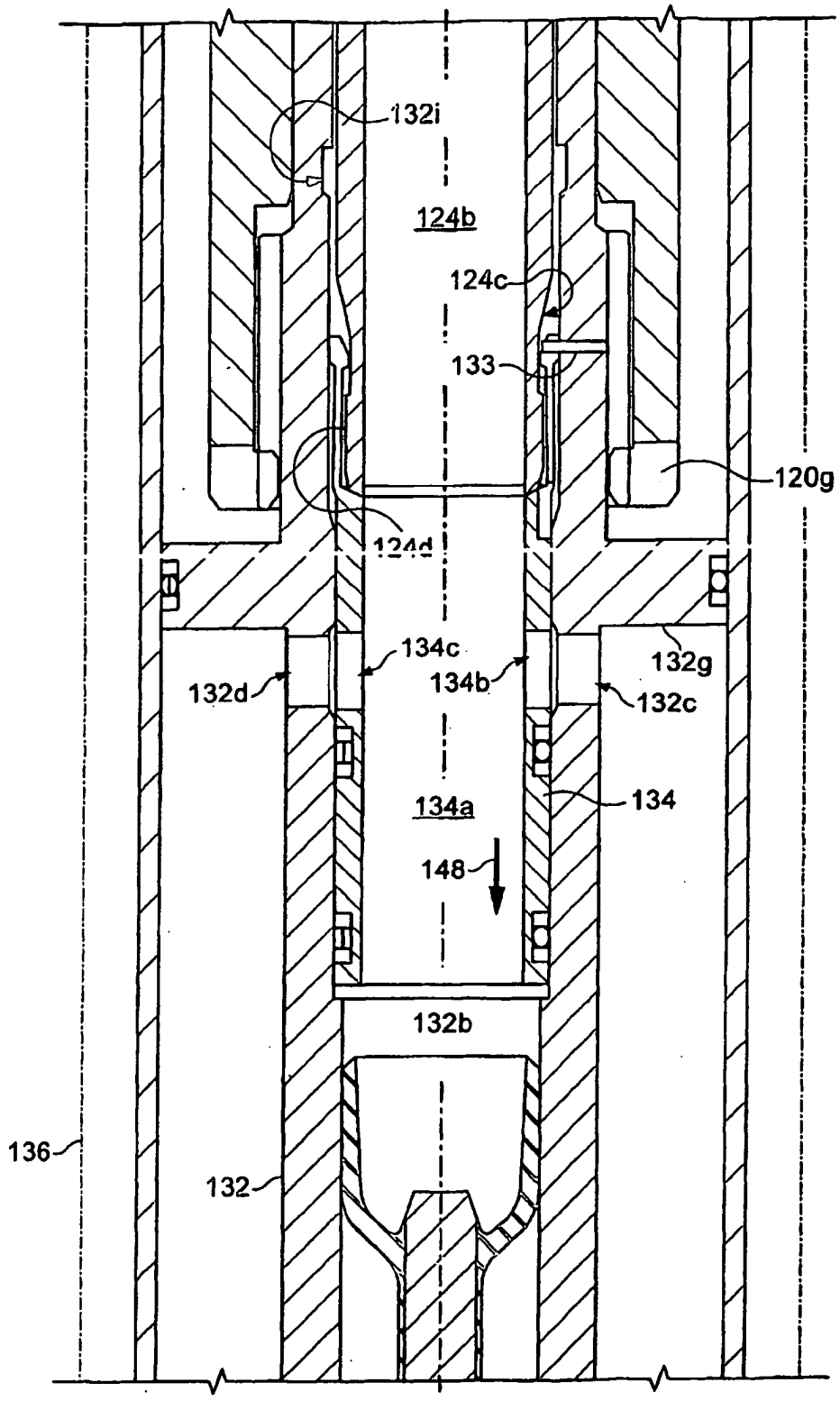
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Fig. 6C

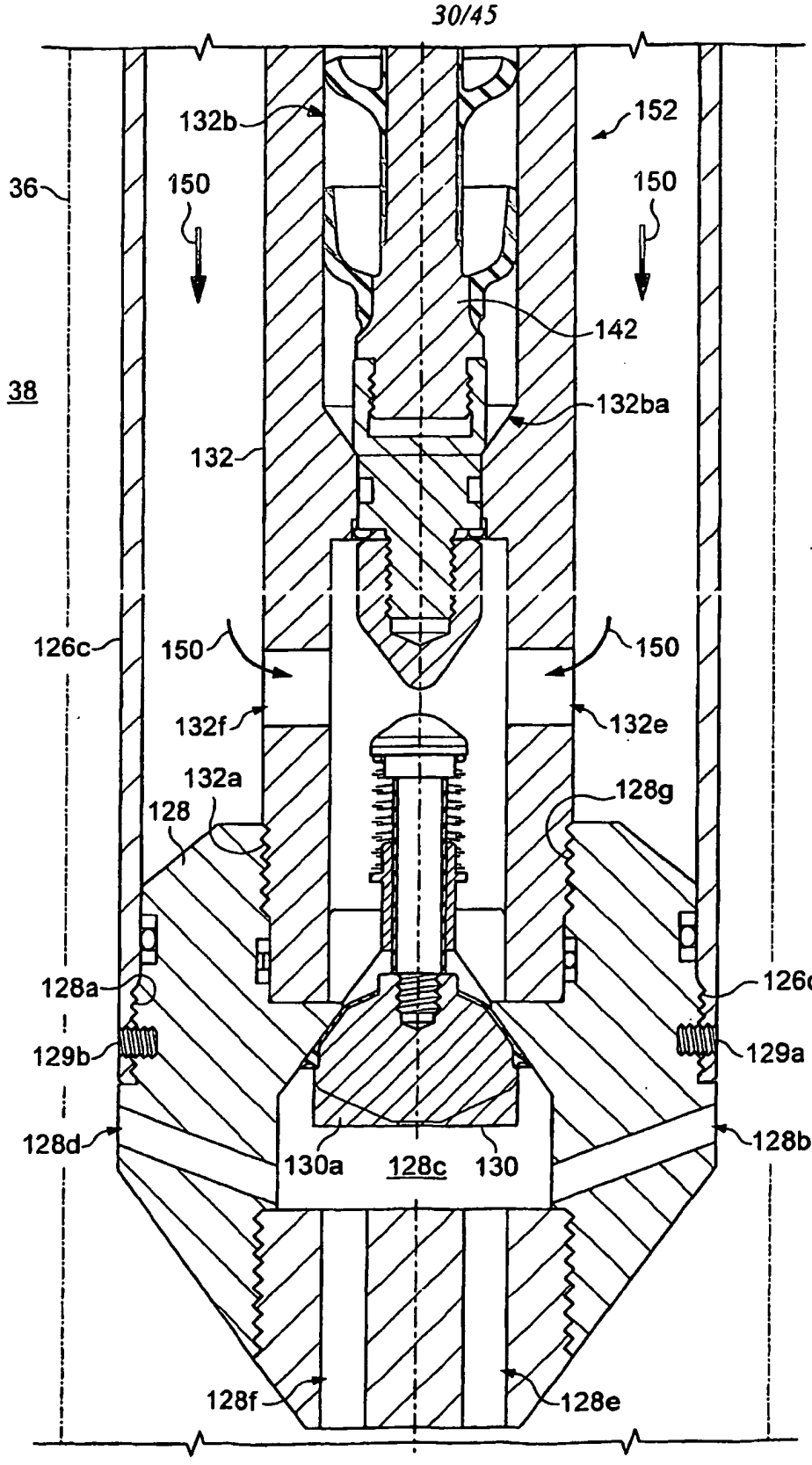
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Fig. 6D

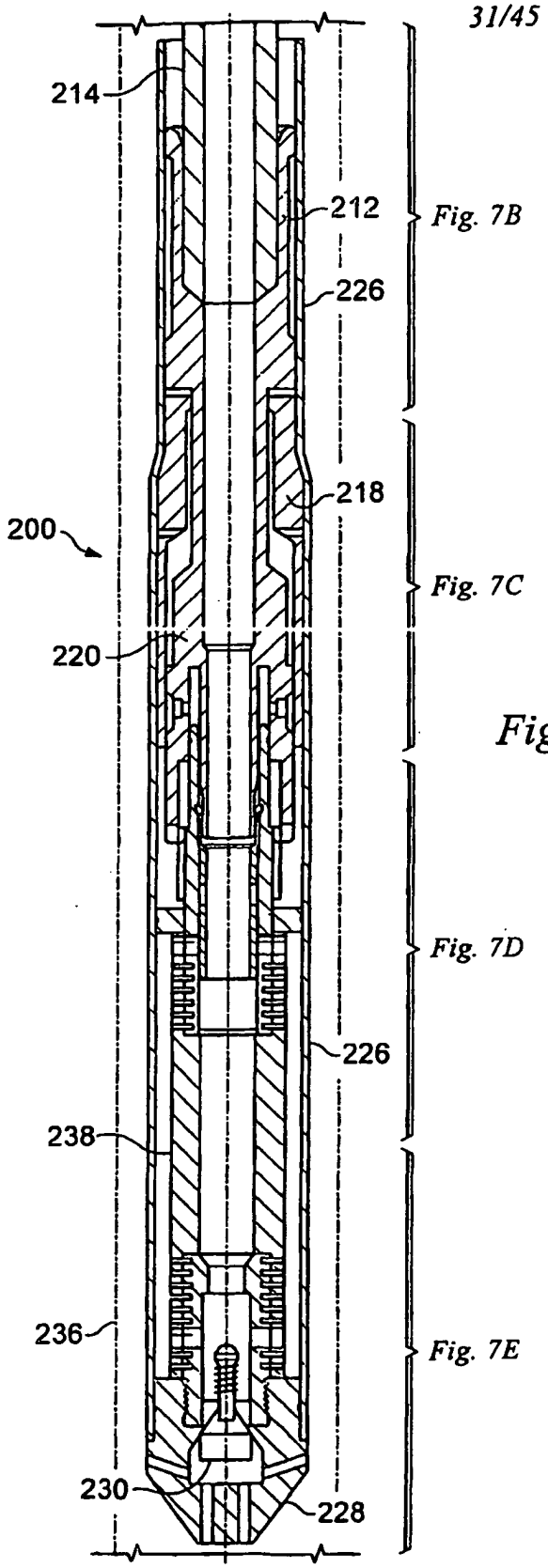
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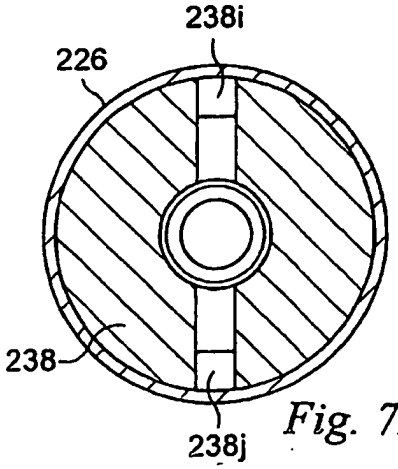
Fig. 7B
Fig. 7C
Fig. 7D
Fig. 7E

Fig. 7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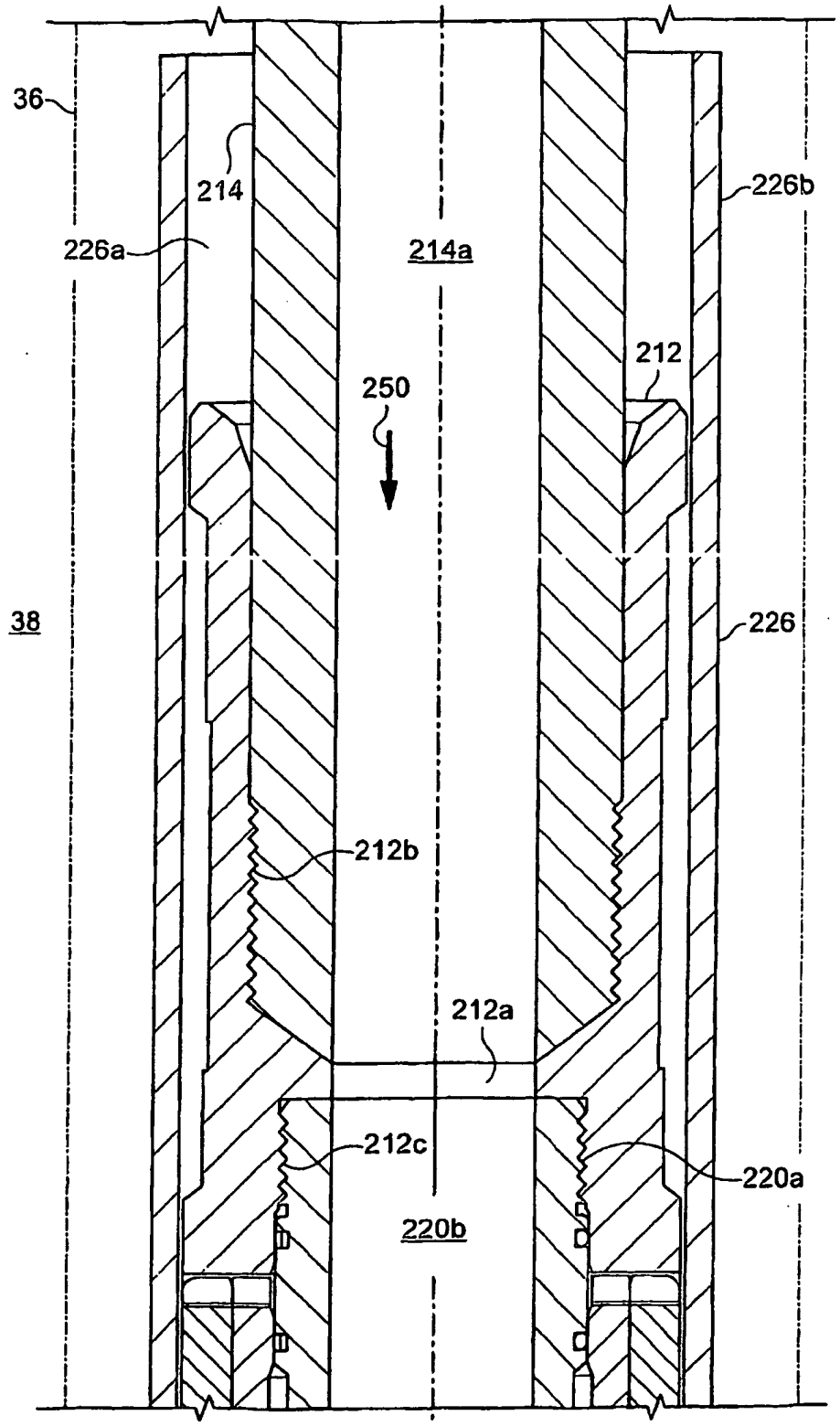

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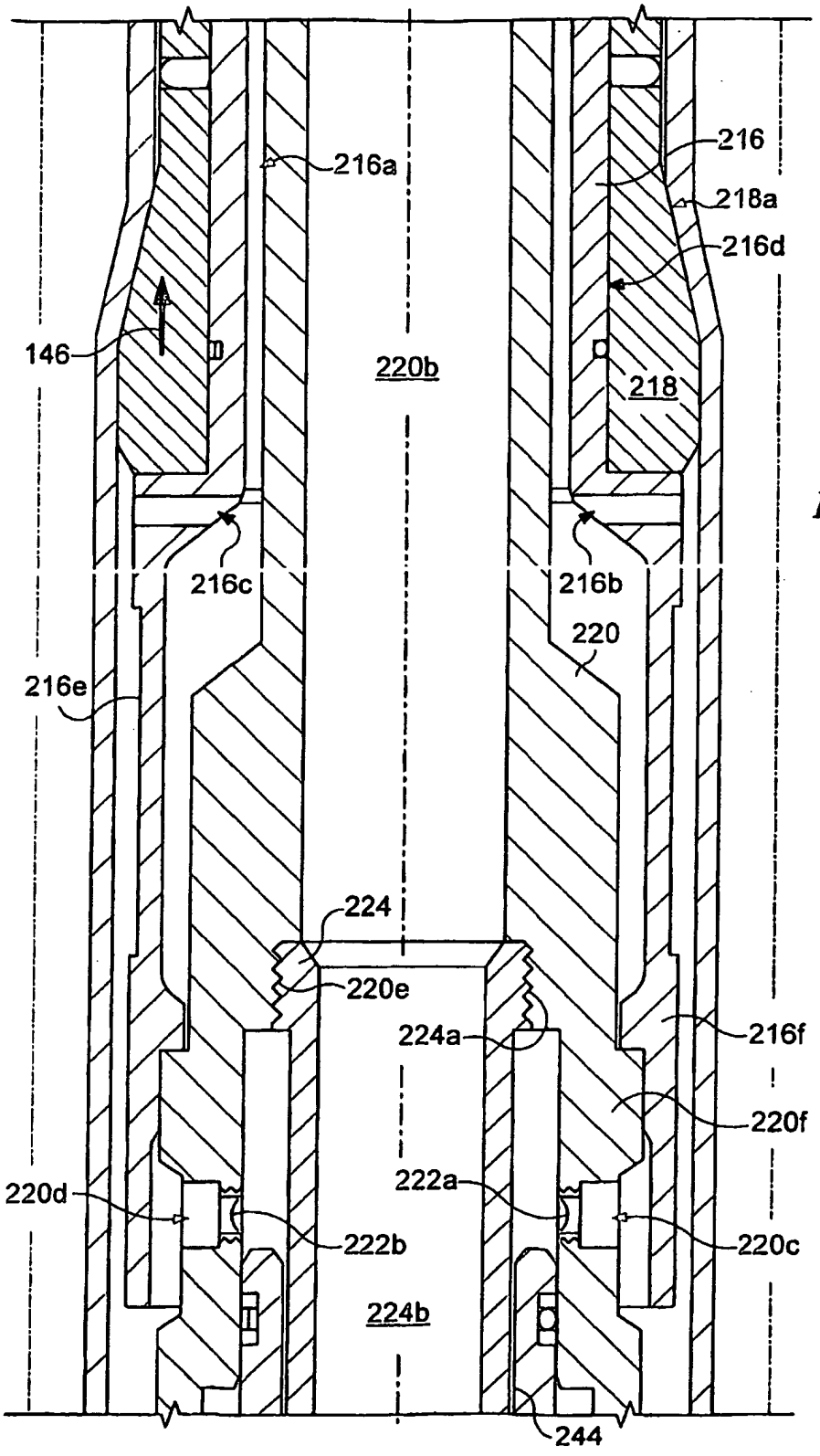
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Fig. 7C

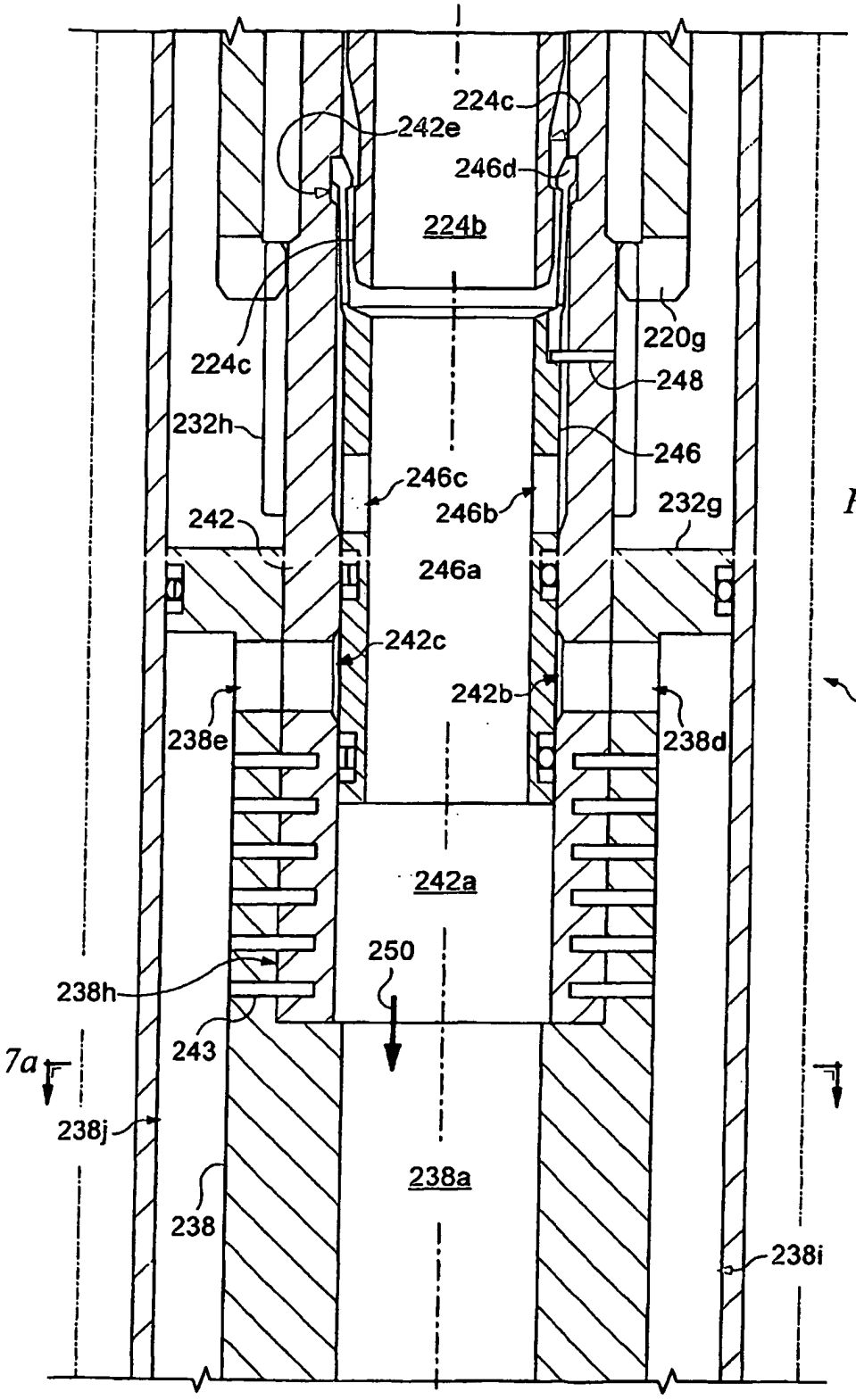
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Fig. 7D

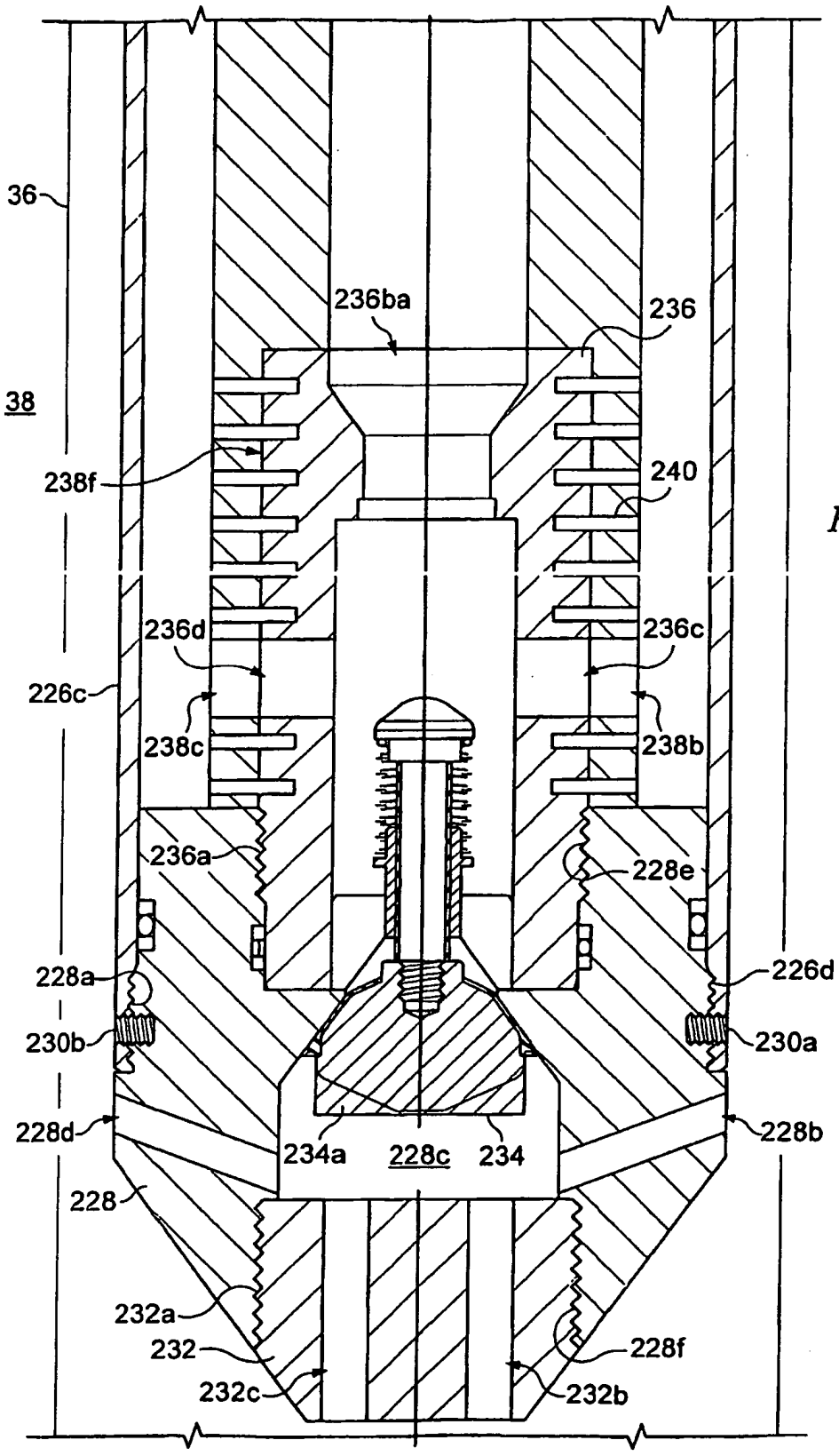
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Fig. 7E

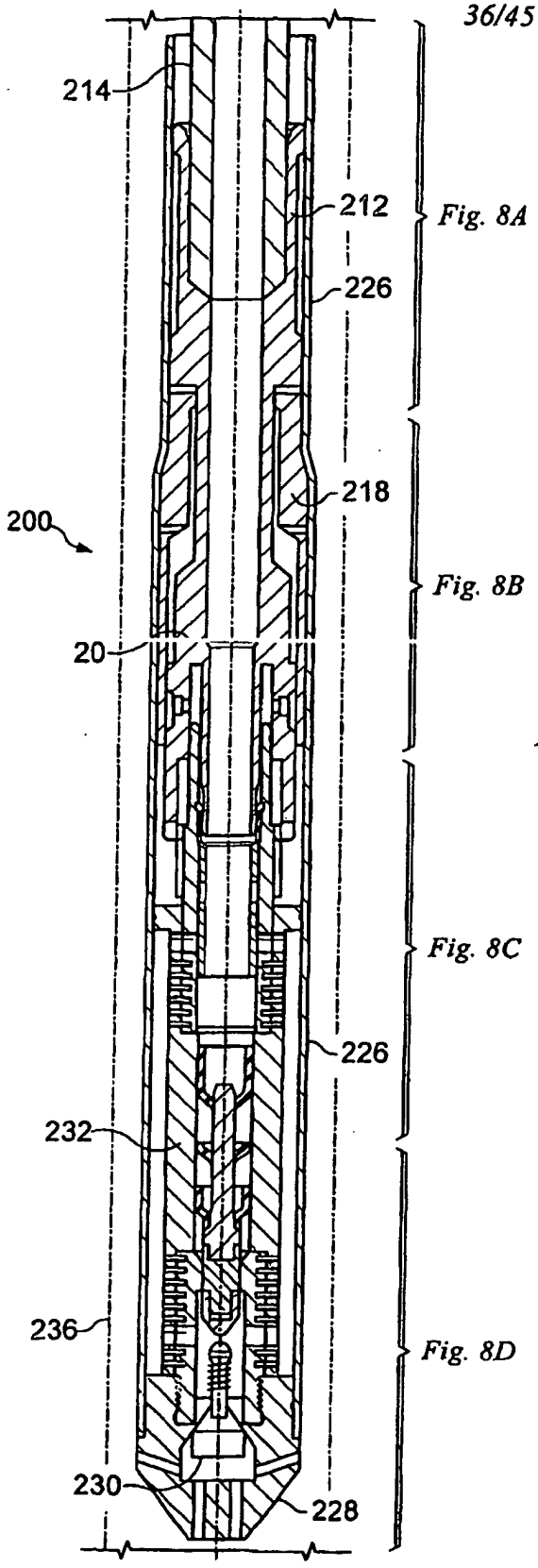
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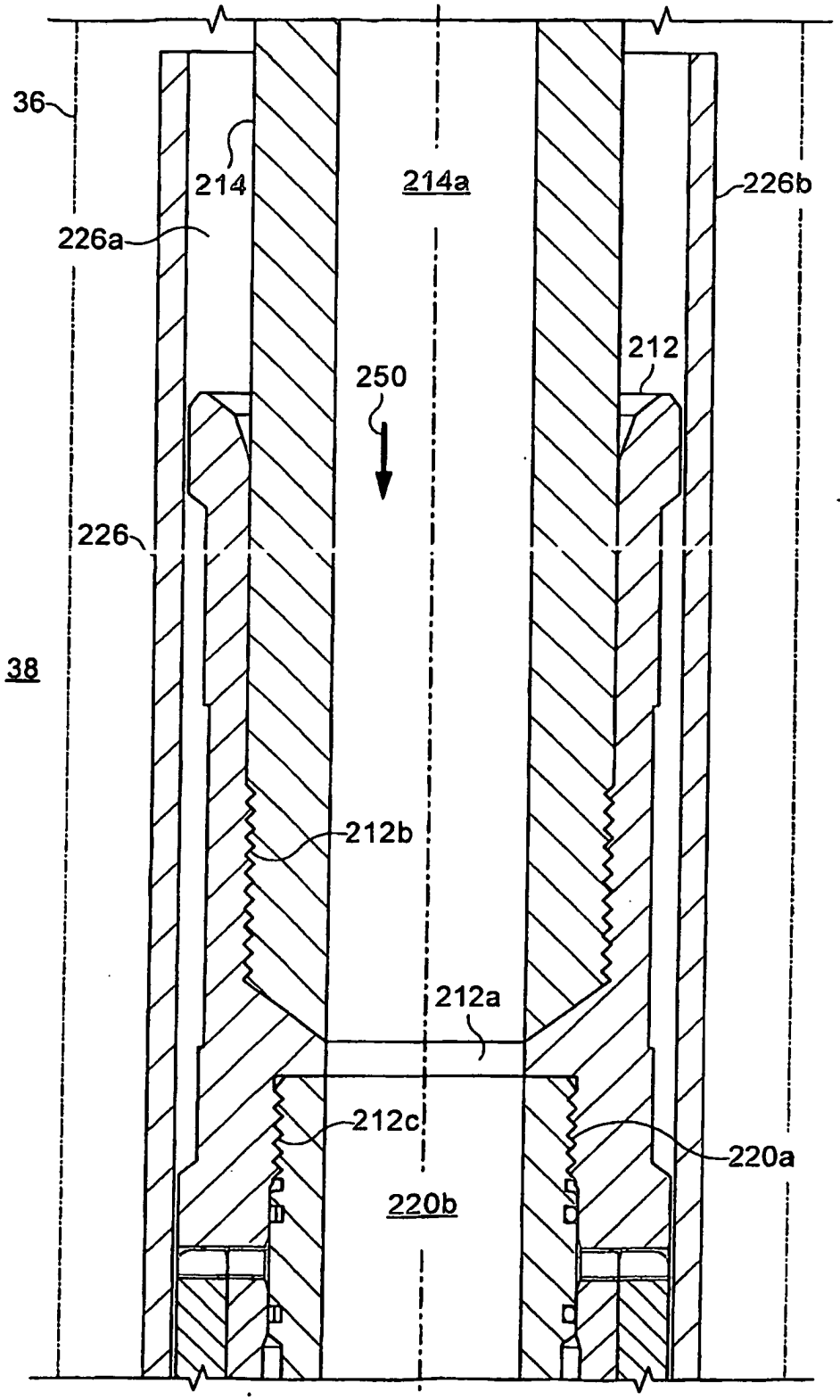
Fig. 8A
Fig. 8B
Fig. 8C
Fig. 8D

Fig. 8



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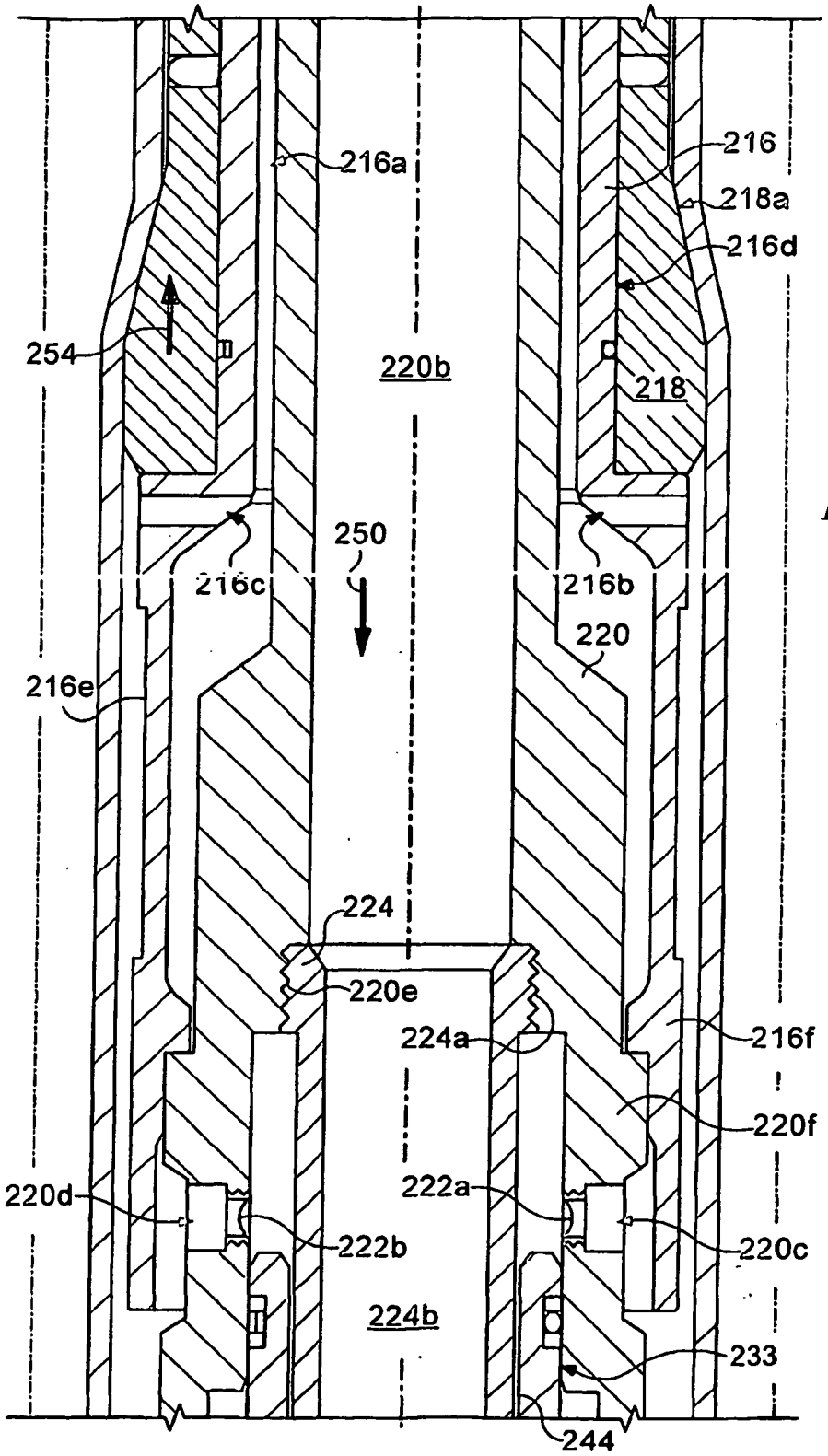
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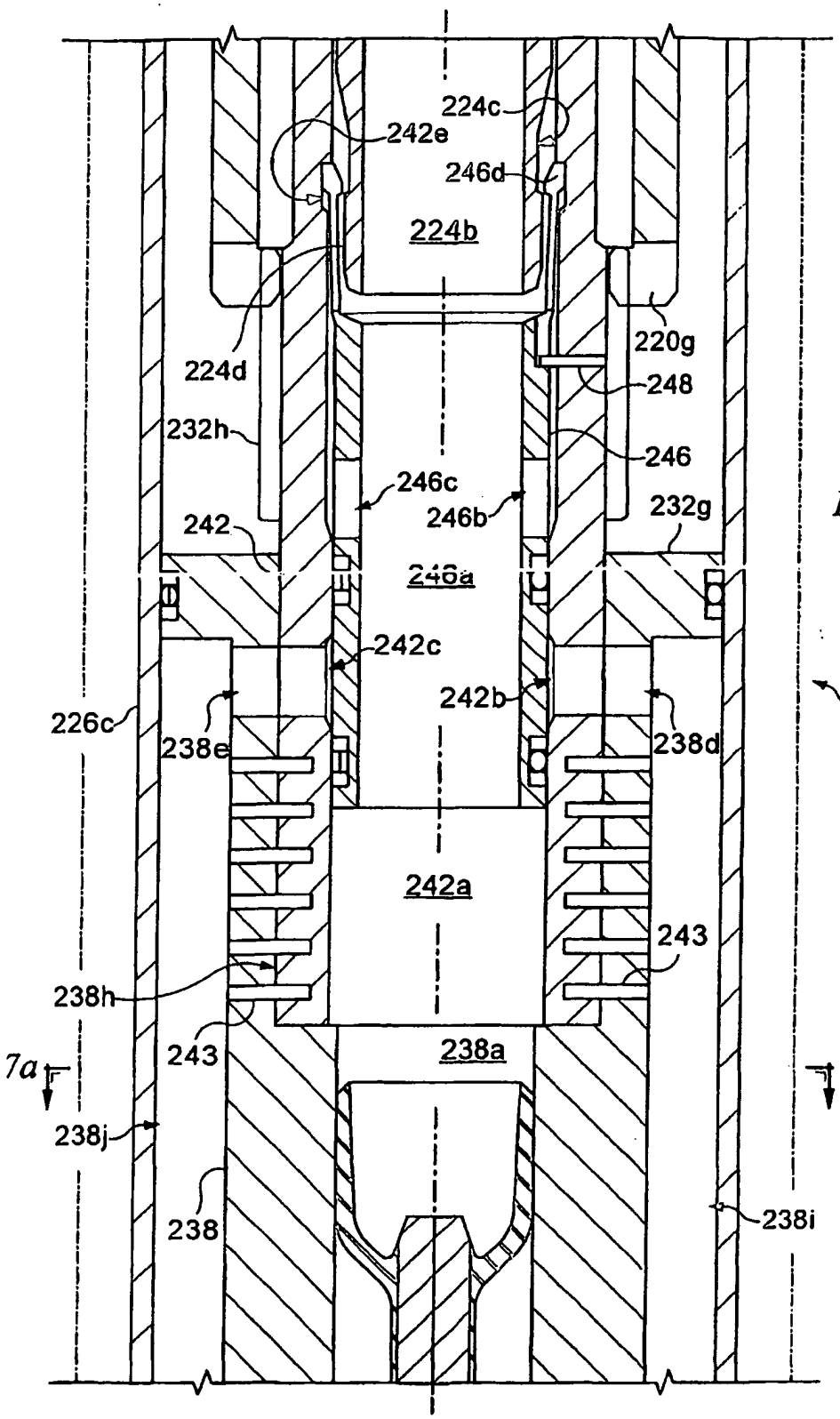
Fig. 8B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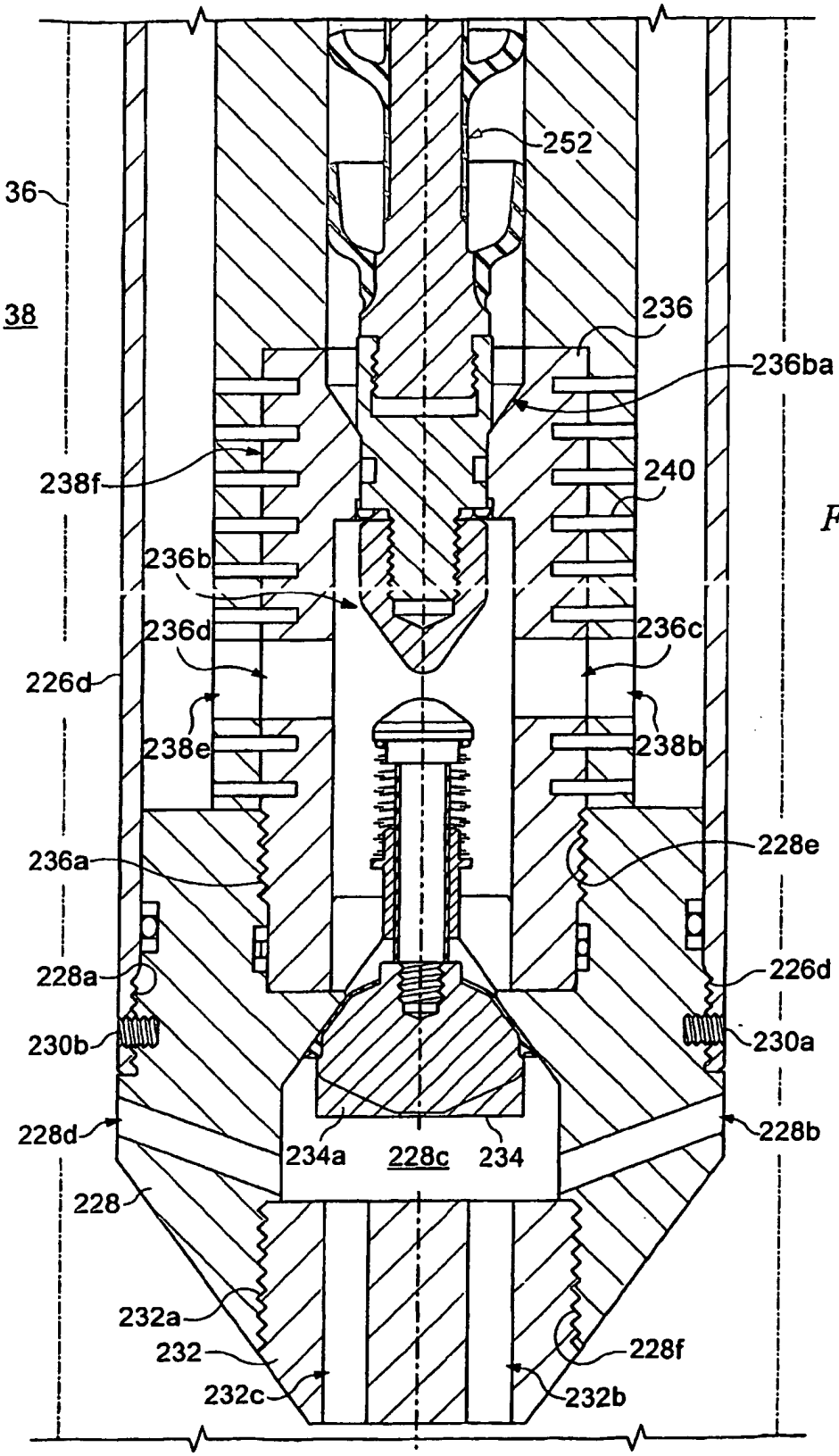
238i

Fig. 8C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38
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238f
240
236b
236d
236c
226d
238e
238b
228e
236a
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226d
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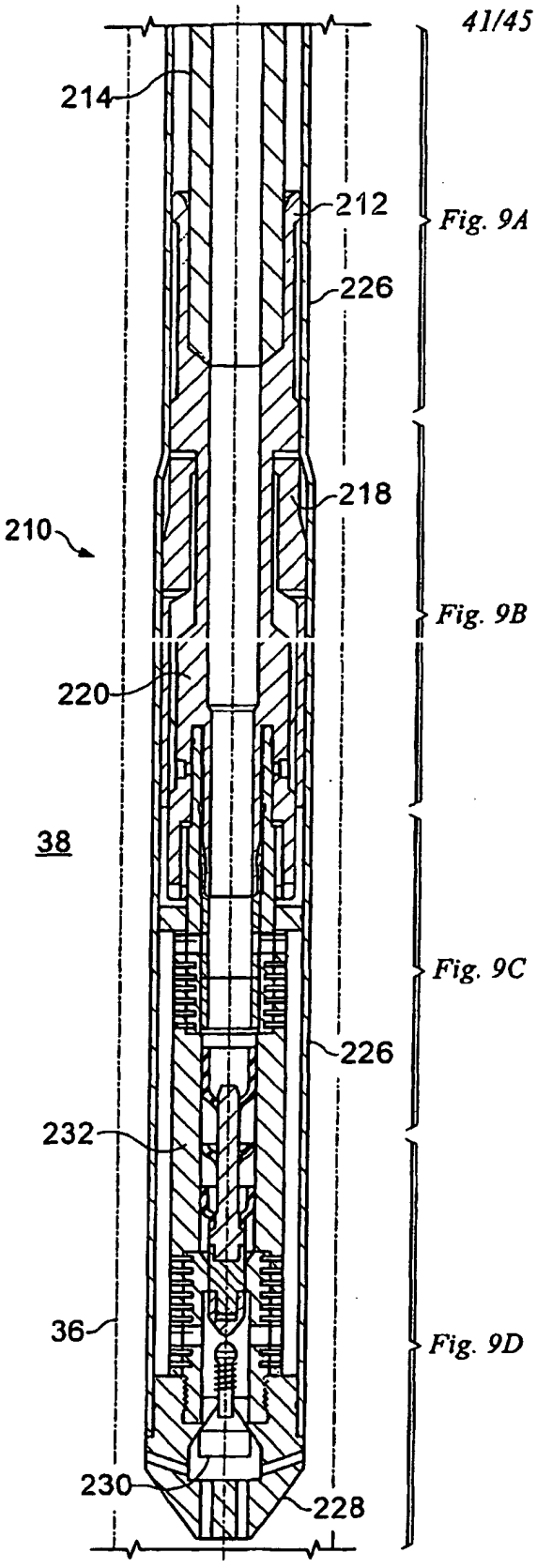
230a
228d
228b
234a
228c
234
228
232a
232
228f
232c
232b

Fig. 8D


214
212
226
218
210
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38
226
232
36
230
228
Fig. 9A
Fig. 9B
Fig. 9C
Fig. 9D

Fig. 9

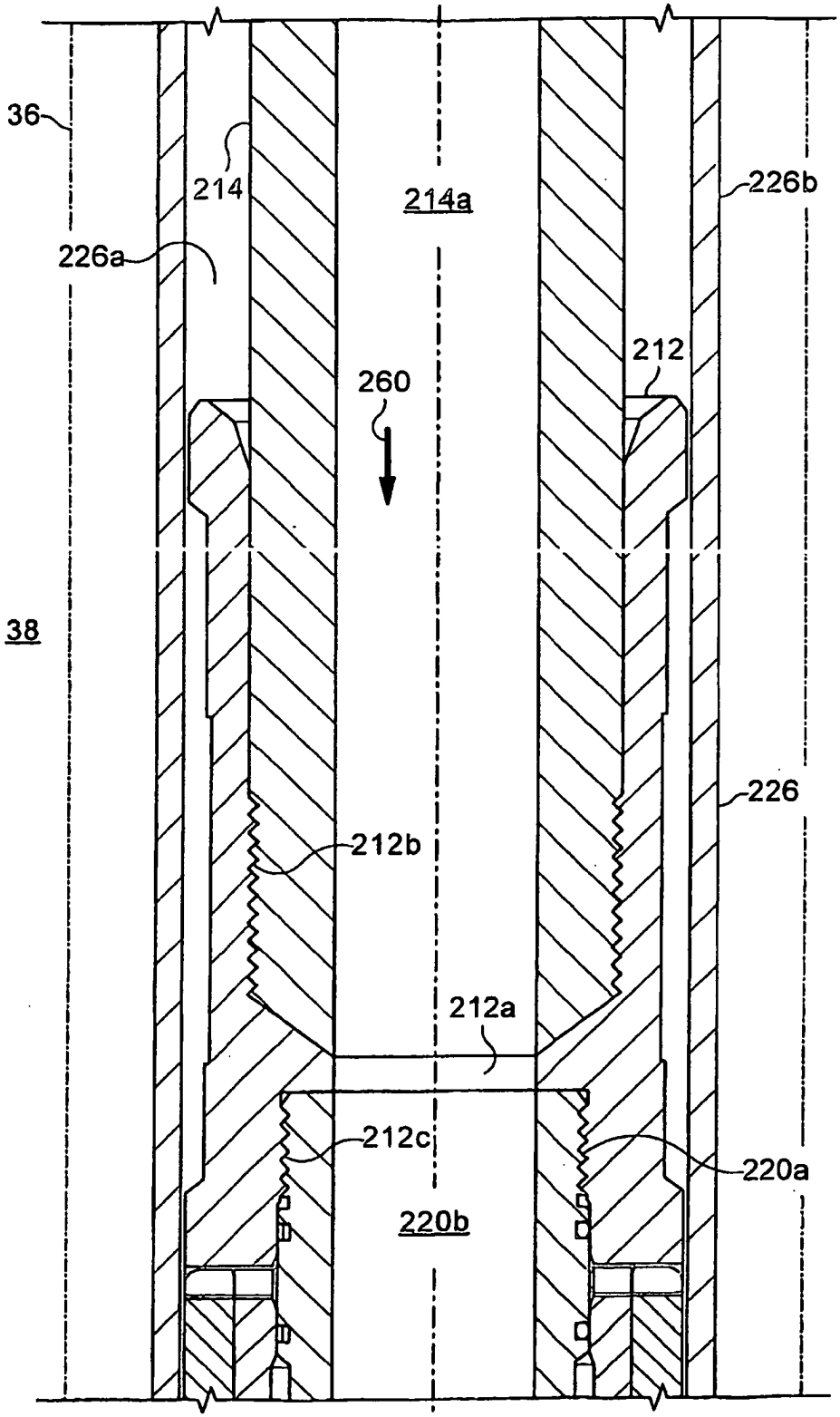
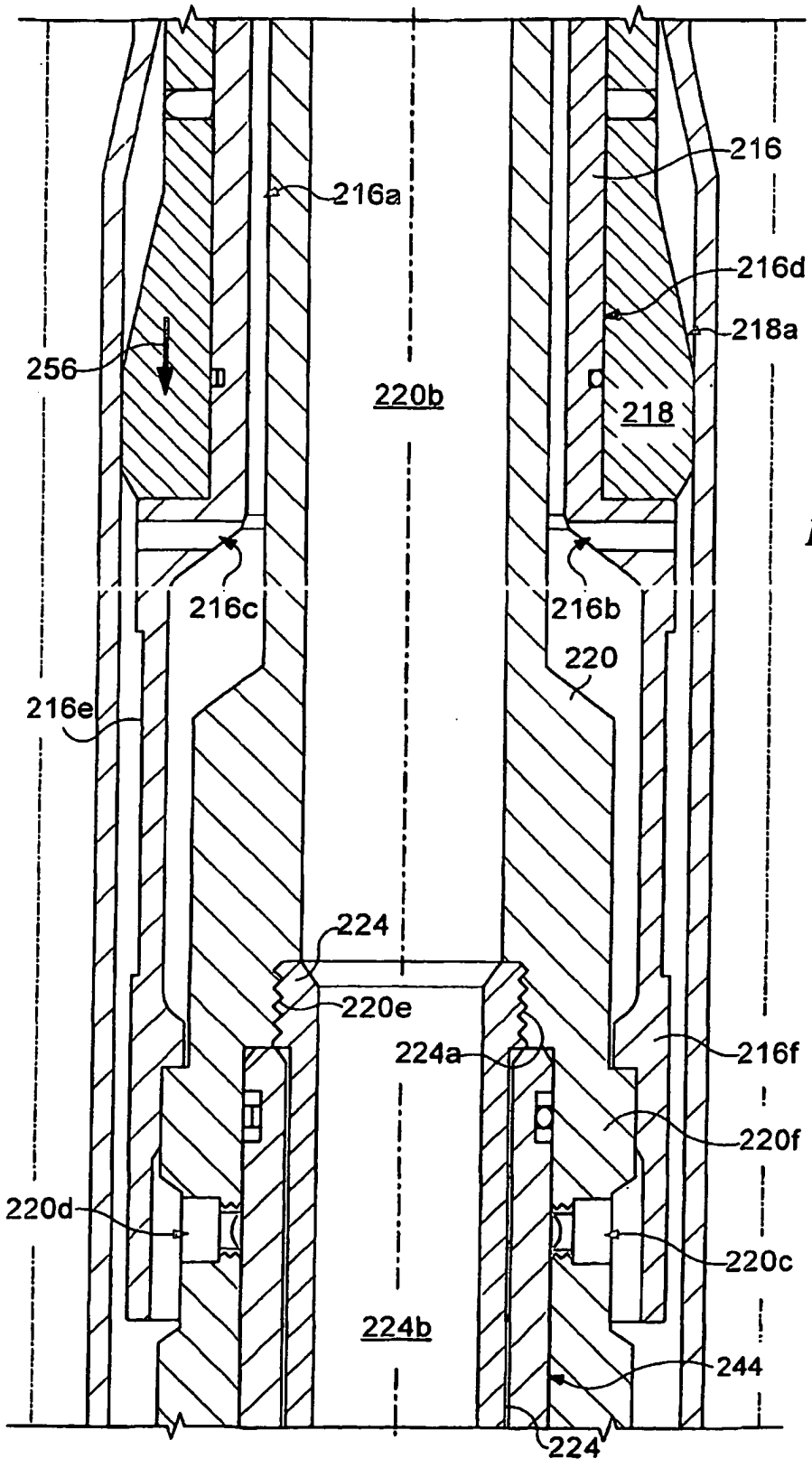


Fig. 9A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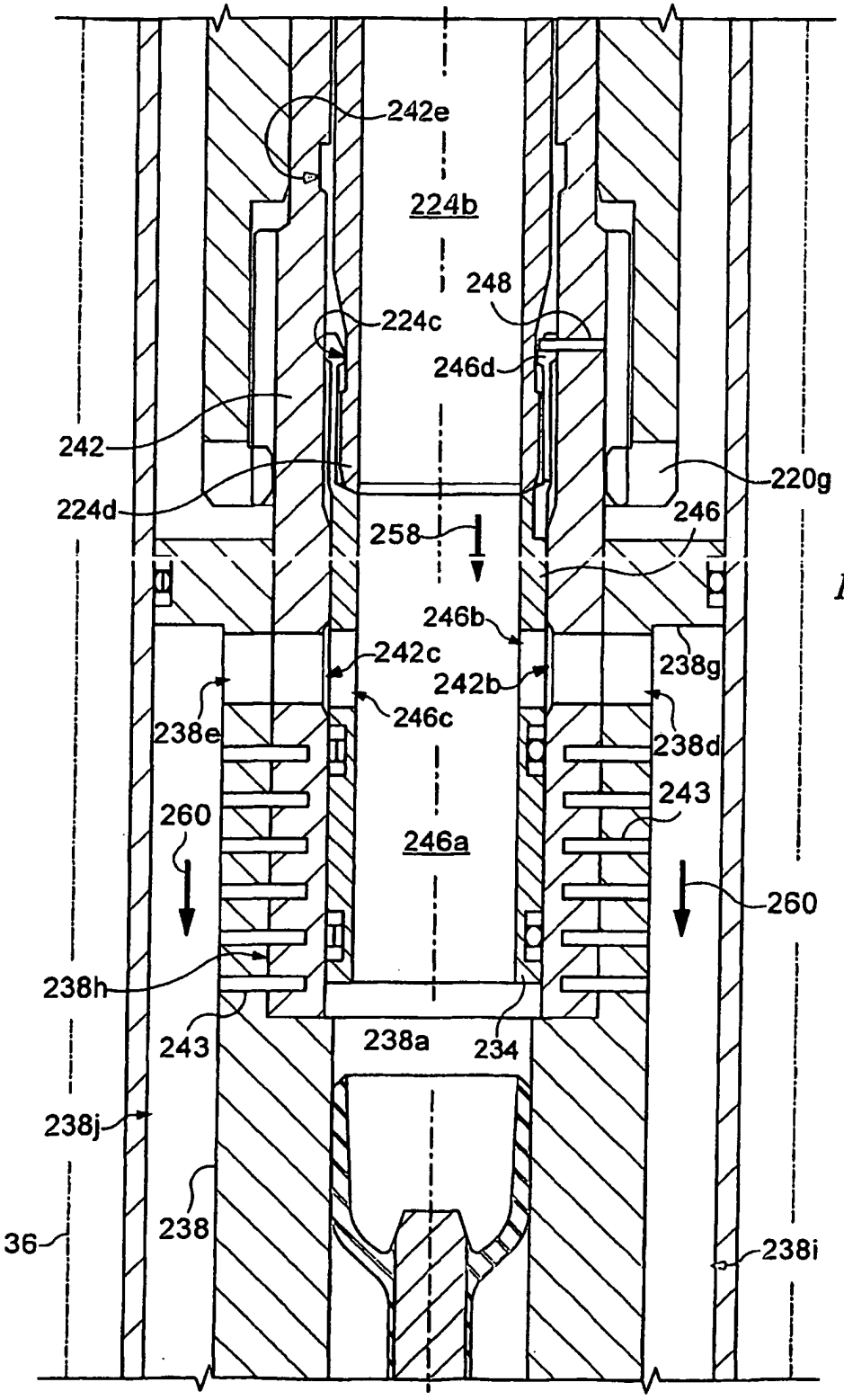
216d
218a
256
220b
218
216c
216b
220
216e
224
220e
224a
216f
220f
220d
220c
224b
244
224

Fig. 9B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224c
246d
242
220g
224d
246
258
246b
242c
238g
242b
238e
246c
238d
243
260
246a
260
238h
243
238a
234
238j
238
36
238i

Fig. 9C

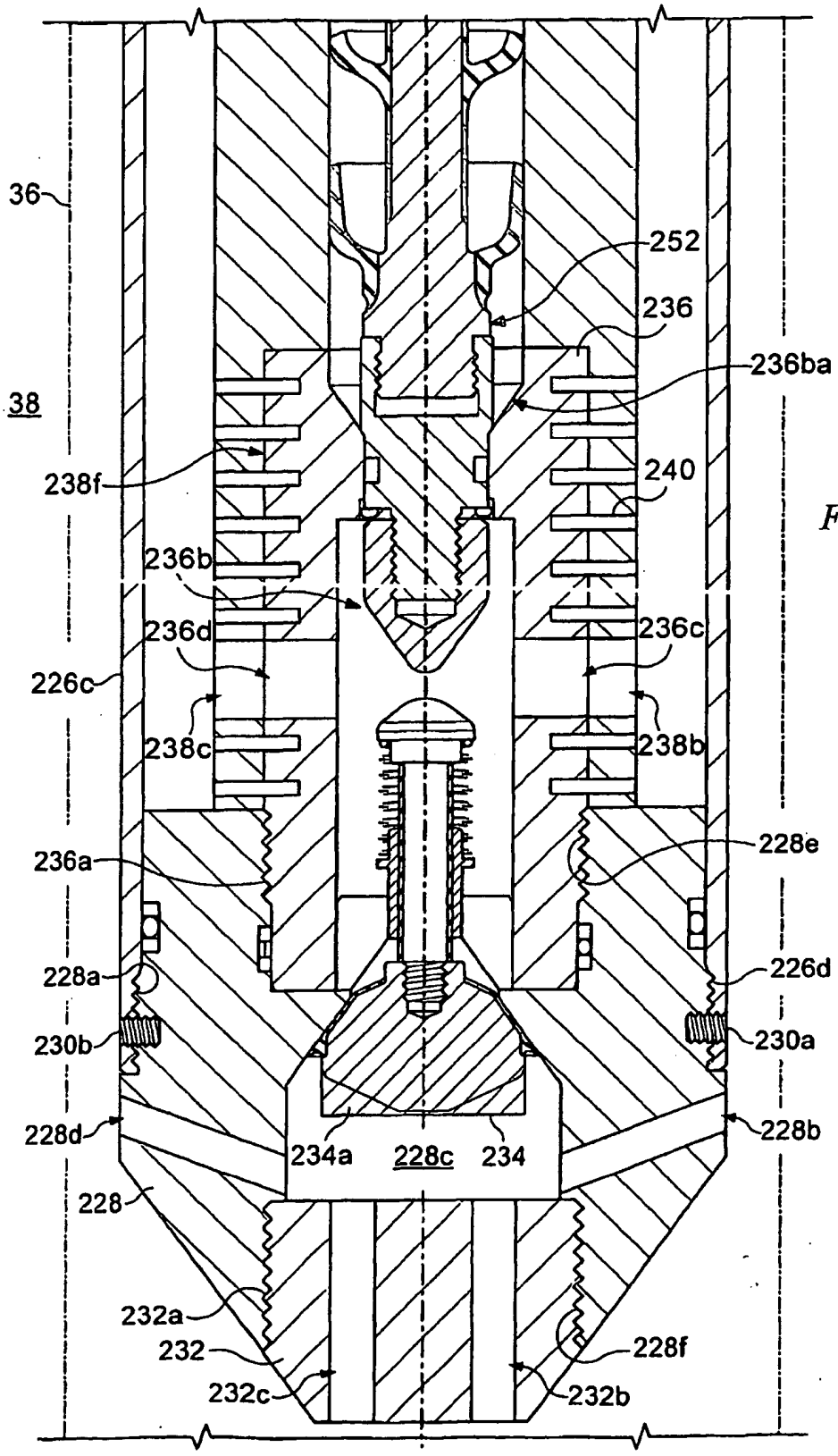
36
38
252
236
236ba
240
238f
236b
236d
236c
226c
238c
238b
228e
236a
228a
226d
230b
230a
228d
228b
234a
228c
234
228
232a
232
228f
232c
232b

Fig. 9D

APPARATUS FOR RADIALLY EXPANDING AND PLASTICALLY DEFORMING A TUBULAR MEMBER

Cross Reference To Related Applications

[001] The present application claims the benefit of the filing date of U.S. provisional patent application serial no. 60/450,504, attorney docket no. 25791.238, filed on February 26, 2003.

[002] This application is related to co-pending application: (1) GB 0518039.3.

Background of the Invention

[003] This invention relates generally to oil and gas exploration, and in particular to forming and repairing wellbore casings to facilitate oil and gas exploration.

Summary Of The Invention

[004] According to an aspect of the present invention, there is provided a system for radially expanding and plastically deforming a tubular member within a preexisting structure, comprising: means for support; means for an internal passage coupled to and positioned within the support means; pressure sensing means for sensing the operating pressure of an injected fluidic material; means for radially expanding and plastically deforming the tubular member within the preexisting structure; means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure; and valve means releasably coupled to the support means said valve means controlling the flow of the fluidic material within the interior of the tubular member.

[005] Preferably, the means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure comprises: means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure before radially expanding and plastically deforming the tubular member within the preexisting structure.

[006] Preferably, the means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure comprises: means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure before or after radially expanding and plastically deforming the tubular member within the preexisting structure.

[007] According to another aspect of the present invention, there is provided an apparatus for radially expanding and plastically deforming an expandable tubular member, comprising: a support member; a tubular stinger defining an internal passage coupled to and positioned within the support member; an expansion device coupled to the support member comprising a rigid external expansion surface; one or more pressure sensors coupled to the support member; a plastically deformable expandable tubular member coupled to the rigid expansion surface of the expansion device comprising a first portion and a second portion, wherein the inside diameter of the first portion is less than the inside diameter of the second portion; and a movable valve releasably coupled to the support member for controlling the flow of fluidic materials through the interior of the expandable tubular member.

[008] Preferably, the pressure sensors comprise frangible elements.

[009] Preferably the pressure sensors comprise valve elements for controlling the flow of fluidic materials within the interior of the expandable tubular member.

[0010] Preferably the support member defines one or more radial passages; and preferably the valve elements are positioned within corresponding radial passages.

[0011] Preferably a tubular member is movably coupled to the support member that defines an internal passage having a plug seat.

[0012] Preferably the movable valve is received within the internal passage of the tubular member.

[0013] Preferably the tubular member defines one or more radial passages; and preferably the movable valve defines one or more radial passages.

[0014] Preferably the tubular member sealingly engages an interior surface of the expandable tubular member.

[0015] Preferably the tubular member is coupled to the second portion of the expandable tubular member.

[0016] According to another aspect of the present invention, there is provided a method of radially expanding and plastically deforming a tubular member within a preexisting structure, comprising: supporting the tubular member within the preexisting structure with a support member, wherein a tubular stinger defining an internal passage is coupled to and positioned within the tubular support member; injecting fluidic material into the tubular member; controlling the flow of the fluidic material using one or more movable valve elements that are coupled to an end of the tubular member; sensing the operating pressure of the injected fluidic material; if the sensed operating pressure of the injected fluidic material exceeds a predetermined value, then radially expanding and plastically deforming the tubular member within the preexisting structure; and wherein one or more of the valve elements are releasably coupled to the support member.

[0017] Preferably, sensing the operating pressure of the injected fluidic material comprises sensing the operating pressure of the injected fluidic material using a sensor positioned within the expandable tubular member.

[0018] Preferably, the method further comprises if the sensed operating pressure of the injected fluidic material exceeds a predetermined value, then permitting the injected fluidic material to pass through a flow passage within the expandable tubular member.

[0019] Preferably, the method further comprises injecting a hardenable fluidic sealing material through and out of the interior of the expandable tubular member into an annulus between the expandable tubular member and the preexisting structure.

[0020] Preferably, the method further comprises preventing the injected hardenable fluidic sealing material from passing though the flow passage.

[0021] Preferably, the method further comprises injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure before radially expanding and plastically deforming the tubular member within the preexisting structure.

[0022] Preferably, the method further comprises injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure before radially expanding and plastically deforming the tubular member within the preexisting structure.

[0023] Preferably, the method further comprises injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure after radially expanding and plastically deforming the tubular member within the preexisting structure.

Brief Description of the Drawings

[0013] Figs. 1, 1a, 1b, 1c, and 1d are fragmentary cross-sectional illustrations of an embodiment of an apparatus for radially expanding and plastically deforming a tubular member during the placement of the apparatus within a wellbore.

[0014] Figs. 2, 2a, 2b, 2c, and 2d are fragmentary cross-sectional illustrations of the apparatus of Figs. 1, 1a, 1b, 1c, and 1d during the radial expansion and plastic deformation of the tubular member.

[0015] Figs. 3, 3a, 3b, 3c, and 3d are fragmentary cross-sectional illustrations of the apparatus of Figs. 1, 1a, 1b, 1c, and 1d during the injection of a hardenable fluidic sealing material into an annulus between the exterior of the apparatus and the wellbore.

[0016] Figs. 4, 4a, 4b, 4c, and 4d are fragmentary cross-sectional illustrations of an embodiment of an apparatus for radially expanding and plastically deforming a tubular member during the placement of the apparatus within a wellbore.

[0017] Figs. 5, 5a, 5b, 5c, and 5d are fragmentary cross-sectional illustrations of the apparatus of Figs. 4, 4a, 4b, 4c, and 4d during the radial expansion and plastic deformation of the tubular member.

[0018] Figs. 6, 6a, 6b, 6c, and 6d are fragmentary cross-sectional illustrations of the apparatus of Figs. 4, 4a, 4b, 4c, and 4d during the injection of a hardenable fluidic sealing material into an annulus between the exterior of the apparatus and the wellbore.

[0019] Figs. 7, 7a, 7b, 7c, 7d, and 7e are fragmentary cross-sectional illustrations of an embodiment of an apparatus for radially expanding and plastically deforming a tubular member during the placement of the apparatus within a wellbore.

[0020] Figs. 8, 8a, 8b, 8c, and 8d are fragmentary cross-sectional illustrations of the apparatus of Figs. 7, 7a, 7b, 7c, 7d, and 7e during the radial expansion and plastic deformation of the tubular member.

[0021] Figs. 9, 9a, 9b, 9c, and 9d are fragmentary cross-sectional illustrations of the apparatus of Figs. 7, 7a, 7b, 7c, 7d, and 7e during the injection of a hardenable fluidic sealing material into an annulus between the exterior of the apparatus and the wellbore.

Detailed Description of the Illustrative Embodiments

[0022] Referring to Figs. 1, 1a, 1b, 1c, and 1d, an exemplary embodiment of an apparatus 10 for radially expanding and plastically deforming a tubular member includes a tubular support 12 that defines a internal passage 12a and includes a threaded connection 12b at one end and a threaded connection 12c at another end. In an exemplary embodiment, during operation of the apparatus 10, a threaded end of a conventional tubular support member 14 that defines a passage 14a may be coupled to the threaded connection 12b of the tubular support member 12.

[0023] An end of a tubular support 16 that defines an internal passage 16a and radial passages, 16b and 16c, and includes an external annular recess 16d, an external flange 16e, and an internal flange 16f is coupled to the other end of the tubular support 12. A tubular expansion cone 18 that includes a tapered external expansion surface 18a is received within and is coupled to the external annular recess 16d of the tubular support 16 and an end of the tubular expansion cone abuts an end face of the external sleeve 16e of the tubular support.

[0024] A threaded connection 20a of an end of a tubular support 20 that defines an internal passage 20b and radial passages, 20c and 20d, and includes a threaded connection 20e, an external flange 20f, and internal splines 20g at another end is coupled to the threaded connection 12c of the other end of the tubular support 12. In an exemplary embodiment, the external flange 20f of the tubular support 20 abuts the internal flange 16f of the tubular support 16. Rupture discs, 22a and 22b, are received and mounted within the radial passages, 20c and 20d, respectively, of the tubular support 20.

[0025] A threaded connection 24a of an end of a tubular stinger 24 that defines an internal passage 24b and includes an external annular recess 24c and an external flange 24d at another end is coupled to the threaded connection 20e of the tubular support 20. An expandable tubular member 26 that defines an internal passage 26a for receiving the tubular supports 12, 14, 16, and 20 mates with and is supported by the external expansion surface 18a of the tubular expansion cone 18 that includes an upper portion 26b having a smaller inside diameter and a lower portion 26c having a larger inside diameter and a threaded connection 26d.

[0026] A threaded connection 28a of a shoe 28 that defines internal passages, 28b, 28c, 28d, 28e, and 28f, and includes another threaded connection 28g is coupled to the threaded connection 26d of the lower portion 26c of the expandable tubular member 26. A conventional one-way poppet valve 30 is movably coupled to the shoe 28 and includes a valve element 30a for controllably sealing an opening of the internal passage 28c of the shoe. In an exemplary embodiment, the one-way poppet valve 30 only permits fluidic materials to be exhausted from the apparatus 10.

[0027] A threaded connection 32a at an end of a tubular body 32 that defines an internal passage 32b, having a plug valve seat 32ba, upper flow ports, 32c and 32d, and lower flow ports, 32e and 32f, and includes an external flange 32g for sealingly engaging the interior surface of the expandable tubular member 26, external splines 32h for mating with and engaging the internal splines 20g of the tubular support 20, and an internal annular recess 32i is coupled to the threaded connection 28g of the shoe 28. Another end of the tubular body 32 is received within an annulus defined between the interior surface of the other end

of the tubular support 20 and the exterior surface of the tubular stinger 24, and sealingly engages the interior surface of the tubular support 20.

[0028] A sliding sleeve valve 34 is movably received and supported within the internal passage 32b of the tubular body 32 that defines an internal passage 34a and radial passages, 34b and 34c, and includes collet fingers 34d at one end positioned within the annular recess 32i of the tubular body for releasably engaging the external flange 24d of the tubular stinger 24. The sliding sleeve valve 34 sealingly engages the internal surface of the internal passage 32b of the tubular body 32, and blocks the upper flow ports, 32c and 32d, of the tubular body. A valve guide pin 33 is coupled to the tubular body 32 for engaging the collet fingers 34d of the sliding sleeve valve 34 and thereby guiding and limiting the movement of the sliding sleeve valve.

[0029] During operation, as illustrated in Figs. 1, 1a, 1b, 1c, and 1d, the apparatus 10 is positioned within a preexisting structure such as, for example, a wellbore 36 that traverses a subterranean formation 38. In an exemplary embodiment, during or after the positioning of the apparatus 10 within the wellbore 36, fluidic materials 40 may be circulated through and out of the apparatus into the wellbore 36 though the internal passages 14a, 12a, 20b, 24b, 34a, 32b, 28b, 28c, 28d, 28e, and 28f.

[0030] In an exemplary embodiment, as illustrated in Figs. 2, 2a, 2b, 2c, and 2d, during operation of the apparatus 10, a conventional plug valve element 42 may then be injected into the apparatus through the passages 14a, 12a, 20b, 24b, 34a, and 32b until the plug valve element is seated in the plug seat 32ba of the internal passage of the tubular body 32. As a result, the flow of fluidic materials through the lower portion of the internal passage 32b of the tubular body 32 is blocked. Continued injection of fluidic materials 40 into the apparatus 10, following the seating of the plug valve element 42 in the plug seat 32ba of the internal passage of the tubular body 32, pressurizes the internal passage 20b of the tubular support and thereby causes the rupture discs, 22a and 22b, to be ruptured thereby opening the internal passages, 20c and 20d, of the tubular support 20. As a result, fluidic materials 40 are then conveyed through the internal passages, 20c and 20d, and radial passages, 16c and 16d, thereby pressurizing a region within the apparatus 10 below the tubular expansion cone 18. As a result, the tubular support 12, tubular support 14, tubular support 16, tubular expansion cone 18, tubular support 20, and tubular stinger 24 are displaced upwardly in the direction 44 relative to the expandable tubular member 26, shoe 28, tubular body 32, and sliding sleeve valve 34 thereby radially expanding and plastically deforming the expandable tubular member.

[0031] During the continued upward displacement of the tubular support 12, tubular support 14, tubular support 16, tubular expansion cone 18, tubular support 20, and tubular stinger 24 in the direction 44 relative to the expandable tubular member 26, shoe 28, tubular body 32,

and sliding sleeve valve 34, the upward movement of the sliding sleeve valve is prevented by the operation of the valve guide pin 33. Consequently, at some point, the collet fingers 34d of the sliding sleeve valve 34 disengage from the external flange 24d of the tubular stinger 24.

[0032] In an exemplary embodiment, as illustrated in Figs. 3, 3a, 3b, 3c, and 3d, during operation of the apparatus 10, before radially expanding and plastically deforming the expandable tubular member 26, the tubular support 12, tubular support 14, tubular support 16, tubular expansion cone 18, tubular support 20, and tubular stinger 24 are displaced downwardly in the direction 46 relative to the expandable tubular member 26, shoe 28, tubular body 32, and sliding sleeve valve 34 by, for example, setting the apparatus down onto the bottom of the wellbore 36. As a result, the other end of the tubular stinger 24 impacts and displaces the sliding sleeve valve 34 downwardly in the direction 48 thereby aligning the internal passages, 32c and 32d, of the tubular body 32, with the internal passages, 34b and 34c, of the sliding sleeve valve. A hardenable fluidic sealing material 50 may then be injected into the apparatus 10 through the internal passages 14a, 12a, 20b, 24b, and 34a, into and through the internal passages 32c and 32d and 34b and 34c, into and through an annulus 52 defined between the interior of the expandable tubular member 26 and the exterior of the tubular body 32, and then out of the apparatus through the internal passages 32e and 32f of the tubular body and the internal passages 28b, 28c, 28d, 28e, and 28f of the shoe 28 into the annulus between the exterior surface of the expandable tubular member and the interior surface of the wellbore 36. As a result, an annular body of a hardenable fluidic sealing material such as, for example, cement is formed within the annulus between the exterior surface of the expandable tubular member 26 and the interior surface of the wellbore 36. Before, during, or after the curing of the annular body of the hardenable fluidic sealing material, the apparatus may then be operated as described above with reference to Fig. 2 to radially expand and plastically deform the expandable tubular member 26.

[0033] Referring to Figs. 4, 4a, 4b, 4c, and 4d, an exemplary embodiment of an apparatus 100 for radially expanding and plastically deforming a tubular member includes a tubular support 112 that defines a internal passage 112a and includes a threaded connection 112b at one end and a threaded connection 112c at another end. In an exemplary embodiment, during operation of the apparatus 100, a threaded end of a conventional tubular support member 114 that defines a passage 114a may be coupled to the threaded connection 112b of the tubular support member 112.

[0034] An end of a tubular support 116 that defines an internal passage 116a and radial passages, 116b and 116c, and includes an external annular recess 116d, an external flange 116e, and an internal flange 116f is coupled to the other end of the tubular support 112. A

tubular expansion cone 118 that includes a tapered external expansion surface 118a is received within and is coupled to the external annular recess 116d of the tubular support 116 and an end of the tubular expansion cone abuts an end face of the external sleeve 116e of the tubular support.

[0035] A threaded connection 120a of an end of a tubular support 120 that defines an internal passage 120b and radial passages, 120c and 120d, and includes a threaded connection 120e, an external flange 120f, and internal splines 120g at another end is coupled to the threaded connection 112c of the other end of the tubular support 112. In an exemplary embodiment, the external flange 120f of the tubular support 120 abuts the internal flange 116f of the tubular support 116. Rupture discs, 122a and 122b, are received and mounted within the radial passages, 120c and 120d, respectively, of the tubular support 120.

[0036] A threaded connection 124a of an end of a tubular stinger 124 that defines an internal passage 124b and includes an external annular recess 124c and an external flange 124d at another end is coupled to the threaded connection 120e of the tubular support 120. An expandable tubular member 126 that defines an internal passage 126a for receiving the tubular supports 112, 114, 116, and 120 mates with and is supported by the external expansion surface 118a of the tubular expansion cone 118 that includes an upper portion 126b having a smaller inside diameter and a lower portion 126c having a larger inside diameter and a threaded connection 126d.

[0037] A threaded connection 128a of a shoe 128 that defines internal passages, 128b, 128c, 128d, 128e, and 128f, and includes another threaded connection 128g is coupled to the threaded connection 126d of the lower portion 126c of the expandable tubular member 126. Pins, 129a and 129b, coupled to the shoe 128 and the lower portion 126c of the expandable tubular member 126 prevent disengagement of the threaded connections, 126d and 128a, of the expandable tubular member and shoe. A conventional one-way poppet valve 130 is movably coupled to the shoe 128 and includes a valve element 130a for controllably sealing an opening of the internal passage 128c of the shoe. In an exemplary embodiment, the one-way poppet valve 130 only permits fluidic materials to be exhausted from the apparatus 100.

[0038] A threaded connection 132a at an end of a tubular body 132 that defines an internal passage 132b, having a plug valve seat 132ba, upper flow ports, 132c and 132d, and lower flow ports, 132e and 132f, and includes an external flange 132g for sealingly engaging the interior surface of the expandable tubular member 126, external splines 132h for mating with and engaging the internal splines 120g of the tubular support 120, and an internal annular recess 132i is coupled to the threaded connection 128g of the shoe 128. Another end of the tubular body 132 is received within an annulus defined between the interior surface of the other end of the tubular support 120 and the exterior surface of the tubular stinger 124, and

sealingly engages the interior surface of the tubular support 120. An annular passage 133 is further defined between the interior surface of the other end of the tubular body 132 and the exterior surface of the tubular stinger 124.

[0039] A sliding sleeve valve 134 is movably received and supported within the internal passage 132b of the tubular body 132 that defines an internal passage 134a and radial passages, 134b and 134c, and includes collet fingers 134d at one end positioned within the annular recess 132i of the tubular body for releasably engaging the external flange 124d of the tubular stinger 124. The sliding sleeve valve 134 sealingly engages the internal surface of the internal passage 132b of the tubular body 132, and blocks the upper flow ports, 132c and 132d, of the tubular body. A valve guide pin 135 is coupled to the tubular body 132 for engaging the collet fingers 134d of the sliding sleeve valve 134 and thereby guiding and limiting the movement of the sliding sleeve valve.

[0040] During operation, as illustrated in Figs. 4, 4a, 4b, 4c, and 4d, the apparatus 100 is positioned within a preexisting structure such as, for example, a wellbore 36 that traverses a subterranean formation 38. In an exemplary embodiment, during or after the positioning of the apparatus 100 within the wellbore 36, fluidic materials 140 may be circulated through and out of the apparatus into the wellbore 36 though the internal passages 114a, 112a, 120b, 124b, 134a, 132b, 128b, 128c, 128d, 128e, and 128f.

[0041] In an exemplary embodiment, as illustrated in Figs. 5, 5a, 5b, 5c, and 5d, during operation of the apparatus 100, a conventional plug valve element 142 may then be injected into the apparatus through the passages 114a, 112a, 120b, 124b, 134a, and 132b until the plug valve element is seated in the plug seat 132ba of the internal passage of the tubular body 132. As a result, the flow of fluidic materials through the lower portion of the internal passage 132b of the tubular body 132 is blocked. Continued injection of fluidic materials 140 into the apparatus 100, following the seating of the plug valve element 142 in the plug seat 132ba of the internal passage of the tubular body 132, pressurizes the internal annular passage 135 and thereby causes the rupture discs, 122a and 122b, to be ruptured thereby opening the internal passages, 120c and 120d, of the tubular support 120. As a result, fluidic materials 140 are then conveyed through the internal passages, 120c and 120d, thereby pressurizing a region within the apparatus 100 below the tubular expansion cone 118. As a result, the tubular support 112, tubular support 114, tubular support 116, tubular expansion cone 118, tubular support 120, and tubular stinger 124 are displaced upwardly in the direction 144 relative to the expandable tubular member 126, shoe 128, tubular body 132, and sliding sleeve valve 134 thereby radially expanding and plastically deforming the expandable tubular member.

[0042] During the continued upward displacement of the tubular support 112, tubular support 114, tubular support 116, tubular expansion cone 118, tubular support 120, and

tubular stinger 124 in the direction 144 relative to the expandable tubular member 126, shoe 128, tubular body 132, and sliding sleeve valve 134, the upward movement of the sliding sleeve valve is prevented by the operation of the valve guide pin 135. Consequently, at some point, the collet fingers 134d of the sliding sleeve valve 134 disengage from the external flange 124d of the tubular stinger 124.

[0043] In an exemplary embodiment, as illustrated in Figs. 6, 6a, 6b, 6c, and 6d, during operation of the apparatus 100, before or after radially expanding and plastically deforming the expandable tubular member 126, the tubular support 112, tubular support 114, tubular support 116, tubular expansion cone 118, tubular support 120, and tubular stinger 124 are displaced downwardly in the direction 146 relative to the expandable tubular member 126, shoe 128, tubular body 132, and sliding sleeve valve 134 by, for example, setting the apparatus down onto the bottom of the wellbore 36. As a result, the end of the tubular body 132 that is received within the annulus defined between the interior surface of the other end of the tubular support 120 and the exterior surface of the tubular stinger 124 and that sealingly engages the interior surface of the tubular support 120 is displaced upwardly relative to the tubular support and tubular stinger thereby preventing fluidic materials from passing through the annular passage 133 into the radial passages, 120c and 120d, of the tubular support. Furthermore, as a result, the other end of the tubular stinger 124 impacts and displaces the sliding sleeve valve 134 downwardly in the direction 148 thereby aligning the internal passages, 132c and 132d, of the tubular body 132, with the internal passages, 134b and 134c, respectively, of the sliding sleeve valve. A hardenable fluidic sealing material 150 may then be injected into the apparatus 100 through the internal passages 114a, 112a, 120b, 124b, and 134a, into and through the internal passages 132c and 132d and 134b and 134c, into and through an annulus 152 defined between the interior of the expandable tubular member 126 and the exterior of the tubular body 132, and then out of the apparatus through the internal passages 132e and 132f of the tubular body and the internal passages 128b, 128c, 128d, 128e, and 128f of the shoe 128 into the annulus between the exterior surface of the expandable tubular member and the interior surface of the wellbore 36. As a result, an annular body of a hardenable fluidic sealing material such as, for example, cement is formed within the annulus between the exterior surface of the expandable tubular member 126 and the interior surface of the wellbore 36. Before, during, or after the curing of the annular body of the hardenable fluidic sealing material, the apparatus may then be operated as described above with reference to Fig. 5 to radially expand and plastically deform the expandable tubular member 126.

[0044] Referring to Figs. 7, 7a, 7b, 7c, 7d and 7e, an exemplary embodiment of an apparatus 200 for radially expanding and plastically deforming a tubular member includes a tubular support 212 that defines a internal passage 212a and includes a threaded

connection 212b at one end and a threaded connection 212c at another end. In an exemplary embodiment, during operation of the apparatus 200, a threaded end of a conventional tubular support member 214 that defines a passage 214a may be coupled to the threaded connection 212b of the tubular support member 212.

[0045] An end of a tubular support 216 that defines an internal passage 216a and radial passages, 216b and 216c, and includes an external annular recess 216d, an external flange 216e, and an internal flange 216f is coupled to the other end of the tubular support 212. A tubular expansion cone 218 that includes a tapered external expansion surface 218a is received within and is coupled to the external annular recess 216d of the tubular support 216 and an end of the tubular expansion cone abuts an end face of the external sleeve 216e of the tubular support.

[0046] A threaded connection 220a of an end of a tubular support 220 that defines an internal passage 220b and radial passages, 220c and 220d, and includes a threaded connection 220e, an external flange 220f, and internal splines 220g at another end is coupled to the threaded connection 212c of the other end of the tubular support 212. In an exemplary embodiment, the external flange 220f of the tubular support 220 abuts the internal flange 216f of the tubular support 216. Rupture discs, 222a and 222b, are received and mounted within the radial passages, 220c and 220d, respectively, of the tubular support 220.

[0047] A threaded connection 224a of an end of a tubular stinger 224 that defines an internal passage 224b and includes an external annular recess 224c and an external flange 224d at another end is coupled to the threaded connection 220e of the tubular support 220. An expandable tubular member 226 that defines an internal passage 226a for receiving the tubular supports 212, 214, 216, and 220 mates with and is supported by the external expansion surface 218a of the tubular expansion cone 218 that includes an upper portion 226b having a smaller inside diameter and a lower portion 226c having a larger inside diameter and a threaded connection 226d.

[0048] A threaded connection 228a of a shoe 228 that defines internal passages, 228b, 228c, and 228d, and includes a threaded connection 228e at one end and a threaded connection 228f at another end is coupled to the threaded connection 226d of the lower portion 226c of the expandable tubular member 226. Pins, 230a and 230b, coupled to the shoe 228 and the lower portion 226c of the expandable tubular member 226 prevent disengagement of the threaded connections, 226d and 228a, of the expandable tubular member and shoe. A threaded connection 232a of a shoe insert 232 that defines internal passages 232b and 232c is coupled to the threaded connection 228f of the shoe 228. In an exemplary embodiment, the shoe 228 and/or the shoe insert 232 are fabricated from composite materials in order to reduce the weight and cost of the components.

[0049] A conventional one-way poppet valve 234 is movably coupled to the shoe 228 and includes a valve element 234a for controllably sealing an opening of the internal passage 228c of the shoe. In an exemplary embodiment, the one-way poppet valve 234 only permits fluidic materials to be exhausted from the apparatus 200.

[0050] A threaded end 236a of a tubular plug seat 236 that defines an internal passage 236b having a plug seat 236ba and lower flow ports, 236c and 236d, is coupled to the threaded connection 228e of the shoe 228. In an exemplary embodiment, the tubular plug seat 236 is fabricated from aluminum in order to reduce weight and cost of the component. A tubular body 238 defines an internal passage 238a, lower flow ports, 238b and 238c, and upper flow ports, 238d and 238e, and includes an internal annular recess 238f at one end that mates with and receives the other end of the tubular plug seat 236, and an internal annular recess 238g and an external flange 238h for sealingly engaging the interior surface of the expandable tubular member 226 at another end. In an exemplary embodiment, the tubular body 238 is fabricated from a composite material in order to reduce weight and cost of the component.

[0051] In an exemplary embodiment, as illustrated in Fig. 7a, the tubular body 238 further defines longitudinal passages, 238i and 238j, for fluidicly coupling the upper and lower flow ports, 238d and 238e and 238b and 238c, respectively.

[0052] One or more retaining pins 240 couple the other end of the tubular plug seat 236 to the internal annular recess 238f of the tubular body.

[0053] An end of a sealing sleeve 242 that defines an internal passage 242a and upper flow ports, 242b and 242c, and includes external splines 242d that mate with and receive the internal splines 220g of the tubular support 220 and an internal annular recess 242e is received within and mates with the internal annular recess 238g at the other end of the tubular body. The other end of the sealing sleeve 242 is received within an annulus defined between the interior surface of the other end of the tubular support 220 and the exterior surface of the tubular stinger 224, and sealingly engages the interior surface of the other end of the tubular support 220. In an exemplary embodiment, the sealing sleeve 242 is fabricated from aluminum in order to reduce weight and cost of the component. One or more retaining pins 243 coupled the end of the sealing sleeve 242 to the internal annular recess 238g at the other end of the tubular body 238. An annular passage 244 is further defined between the interior surface of the other end of the tubular body sealing sleeve 242 and the exterior surface of the tubular stinger 224.

[0054] A sliding sleeve valve 246 is movably received and supported within the internal passage 242a of the sealing sleeve 242 that defines an internal passage 246a and radial passages, 246b and 246c, and includes collet fingers 246d at one end positioned within the annular recess 242e of the sealing sleeve for releasably engaging the external flange 224d

of the tubular stinger 224. The sliding sleeve valve 246 sealingly engages the internal surface of the internal passage 242a of the sealing sleeve 242, and blocks the upper flow ports, 242b and 242c and 238d and 238e, of the sealing sleeve and the tubular body, respectively. A valve guide pin 248 is coupled to the sealing sleeve 242 for engaging the collet fingers 246d of the sliding sleeve valve 246 and thereby guiding and limiting the movement of the sliding sleeve valve.

[0055] During operation, as illustrated in Figs. 7, 7a, 7b, 7c, 7d and 7e, the apparatus 200 is positioned within a preexisting structure such as, for example, a wellbore 36 that traverses a subterranean formation 38. In an exemplary embodiment, during or after the positioning of the apparatus 200 within the wellbore 36, fluidic materials 250 may be circulated through and out of the apparatus into the wellbore 36 though the internal passages 214a, 212a, 220b, 224b, 246a, 242a, 238a, 236b, 228b, 228c, 228d, 232b, and 232c.

[0056] In an exemplary embodiment, as illustrated in Figs. 8, 8a, 8b, 8c, and 8d, during operation of the apparatus 200, a conventional plug valve element 252 may then be injected into the apparatus through the passages 214a, 212a, 220b, 224b, 246a, 242a, 238a, and 236b until the plug valve element is seated in the plug seat 236ba of the internal passage 236b of the tubular plug seat 236. As a result, the flow of fluidic materials through the lower portion of the internal passage 236b of the tubular plug seat 236 is blocked. Continued injection of fluidic materials 250 into the apparatus 200, following the seating of the plug valve element 252 in the plug seat 236ba of the internal passage 236b of the tubular plug seat 236, pressurizes the internal annular passage 244 and thereby causes the rupture discs, 222a and 222b, to be ruptured thereby opening the internal passages, 220c and 220d, of the tubular support 220. As a result, fluidic materials 250 are then conveyed through the internal passages, 220c and 220d, thereby pressurizing a region within the apparatus 200 below the tubular expansion cone 218. As a result, the tubular support 212, tubular support 214, tubular support 216, tubular expansion cone 218, tubular support 220, and tubular stinger 224 are displaced upwardly in the direction 254 relative to the expandable tubular member 226, shoe 228, shoe insert 232, tubular plug seat 236, tubular body 238, sealing sleeve 242, and sliding sleeve valve 236 thereby radially expanding and plastically deforming the expandable tubular member.

[0057] During the continued upward displacement of the tubular support 212, tubular support 214, tubular support 216, tubular expansion cone 218, tubular support 220, and tubular stinger 224 in the direction 254 relative to the expandable tubular member 226, shoe 228, shoe insert 232, tubular plug seat 236, tubular body 238, sealing sleeve 242, and sliding sleeve valve 236, the upward movement of the sliding sleeve valve is prevented by the operation of the valve guide pin 248. Consequently, at some point, the collet fingers

246d of the sliding sleeve valve 246 disengage from the external flange 224d of the tubular stinger 224.

[0058] In an exemplary embodiment, as illustrated in Figs. 9, 9a, 9b, 9c, and 9d, during operation of the apparatus 200, before or after radially expanding and plastically deforming the expandable tubular member 226, the tubular support 212, tubular support 214, tubular support 216, tubular expansion cone 218, tubular support 220, and tubular stinger 224 are displaced downwardly in the direction 256 relative to the expandable tubular member 226, shoe 228, shoe insert 232, tubular plug seat 236, tubular body 238, sealing sleeve 242, and sliding sleeve valve 236 by, for example, setting the apparatus down onto the bottom of the wellbore 36. As a result, the end of the sealing sleeve 242 that is received within the annulus defined between the interior surface of the other end of the tubular support 220 and the exterior surface of the tubular stinger 224 and that sealingly engages the interior surface of the tubular support 220 is displaced upwardly relative to the tubular support and tubular stinger thereby preventing fluidic materials from passing through the annular passage 244 into the radial passages, 220c and 220d, of the tubular support. Furthermore, as a result, the other end of the tubular stinger 224 impacts and displaces the sliding sleeve valve 246 downwardly in the direction 258 thereby aligning the internal passages, 238d and 238e and 242b and 242c, of the tubular body 238 and sealing sleeve 242, respectively, with the internal passages, 246b and 246c, respectively, of the sliding sleeve valve. A hardenable fluidic sealing material 260 may then be injected into the apparatus 200 through the internal passages 214a, 212a, 220b, 224b, and 246a, into and through the internal passages 238d, 238e, 242b, 242c, 246b and 246c, into and through the longitudinal grooves, 238i and 238j, into and through the internal passages, 236a, 236b, 238b and 238c, and then out of the apparatus through the internal passages 228b, 228c, 228d of the shoe 228f and 232b and 232c of the shoe insert 232 into the annulus between the exterior surface of the expandable tubular member 226 and the interior surface of the wellbore 36. As a result, an annular body of a hardenable fluidic sealing material such as, for example, cement is formed within the annulus between the exterior surface of the expandable tubular member 226 and the interior surface of the wellbore 36. Before, during, or after the curing of the annular body of the hardenable fluidic sealing material, the apparatus may then be operated as described above with reference to Fig. 8 to radially expand and plastically deform the expandable tubular member 226.

[0059] In several exemplary embodiments, the expandable tubular members 26, 126, and/or 226 are radially expanded and plastically deformed using one or more of the methods and apparatus disclosed in one or more of the following: (1) U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application

60/111,293, filed on 12/7/98, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, which claims priority from provisional application 60/121,702, filed on 2/25/99, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, which claims priority from provisional application 60/119,611, filed on 2/11/99, (4) U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (5) U.S. patent application serial no. 10/169,434, attorney docket no. 25791.10.04, filed on 7/1/02, which claims priority from provisional application 60/183,546, filed on 2/18/00, (6) U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (7) U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (8) U.S. patent number 6,575,240, which was filed as patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, which claims priority from provisional application 60/121,907, filed on 2/26/99, (9) U.S. patent number 6,557,640, which was filed as patent application serial no. 09/586,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (10) U.S. patent application serial no. 09/981,916, attorney docket no. 25791.18, filed on 10/18/01 as a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (11) U.S. patent number 6,604,763, which was filed as application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, which claims priority from provisional application 60/131,106, filed on 4/26/99, (12) U.S. patent application serial no. 10/030,593, attorney docket no. 25791.25.08, filed on 1/8/02, which claims priority from provisional application 60/146,203, filed on 7/29/99, (13) U.S. provisional patent application serial no. 60/143,039, attorney docket no. 25791.26, filed on 7/9/99, (14) U.S. patent application serial no. 10/111,982, attorney docket no. 25791.27.08, filed on 4/30/02, which claims priority from provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (15) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (16) U.S. provisional patent application serial no. 60/438,828, attorney docket no. 25791.31, filed on 1/9/03, (17) U.S. patent number 6,564,875, which was filed as application serial no. 09/679,907, attorney docket no. 25791.34.02, on 10/5/00, which claims priority from provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (18) U.S. patent application serial no. 10/089,419, filed on 3/27/02, attorney

docket no. 25791.36.03, which claims priority from provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (19) U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (20) U.S. patent application serial no. 10/303,992, filed on 11/22/02, attorney docket no. 25791.38.07, which claims priority from provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (21) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (22) U.S. provisional patent application serial no. 60/455,051, attorney docket no. 25791.40, filed on 3/14/03, (23) PCT application US02/2477, filed on 6/26/02, attorney docket no. 25791.44.02, which claims priority from U.S. provisional patent application serial no. 60/303,711, attorney docket no. 25791.44, filed on 7/6/01, (24) U.S. patent application serial no. 10/311,412, filed on 12/12/02, attorney docket no. 25791.45.07, which claims priority from provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (25) U.S. patent application serial no. 10/, filed on 12/18/02, attorney docket no. 25791.46.07, which claims priority from provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (26) U.S. patent application serial no. 10/322,947, filed on 1/22/03, attorney docket no. 25791.47.03, which claims priority from provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (27) U.S. patent application serial no. 10/406,648, filed on 3/31/03, attorney docket no. 25791.48.06, which claims priority from provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (28) PCT application US02/04353, filed on 2/14/02, attorney docket no. 25791.50.02, which claims priority from U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001, (29) U.S. patent application serial no. 10/465,835, filed on 6/13/03, attorney docket no. 25791.51.06, which claims priority from provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001, (30) U.S. patent application serial no. 10/465,831, filed on 6/13/03, attorney docket no. 25791.52.06, which claims priority from U.S. provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, (31) U.S. provisional patent application serial no. 60/452,303, filed on 3/5/03, attorney docket no. 25791.53, (32) U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (33) U.S. patent number 6,561,227, which was filed as patent application serial number 09/852,026 , filed on 5/9/01, attorney docket no. 25791.56, as a

divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (34) U.S. patent application serial number 09/852,027, filed on 5/9/01, attorney docket no. 25791.57, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (35) PCT Application US02/25608, attorney docket no. 25791.58.02, filed on 8/13/02, which claims priority from provisional application 60/318,021, filed on 9/7/01, attorney docket no. 25791.58, (36) PCT Application US02/24399, attorney docket no. 25791.59.02, filed on 8/1/02, which claims priority from U.S. provisional patent application serial no. 60/313,453, attorney docket no. 25791.59, filed on 8/20/2001, (37) PCT Application US02/29856, attorney docket no. 25791.60.02, filed on 9/19/02, which claims priority from U.S. provisional patent application serial no. 60/326,886, attorney docket no. 25791.60, filed on 10/3/2001, (38) PCT Application US02/20256, attorney docket no. 25791.61.02, filed on 6/26/02, which claims priority from U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (39) U.S. patent application serial no. 09/962,469, filed on 9/25/01, attorney docket no. 25791.62, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (40) U.S. patent application serial no. 09/962,470, filed on 9/25/01, attorney docket no. 25791.63, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (41) U.S. patent application serial no. 09/962,471, filed on 9/25/01, attorney docket no. 25791.64, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (42) U.S. patent application serial no. 09/962,467, filed on 9/25/01, attorney docket no. 25791.65, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (43) U.S. patent application serial no. 09/962,468, filed on 9/25/01, attorney docket no. 25791.66, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (44) PCT application US 02/25727, filed on 8/14/02, attorney docket no. 25791.67.03, which claims priority from U.S. provisional patent application serial no. 60/317,985, attorney docket no. 25791.67, filed on 9/6/2001, and U.S. provisional patent application serial no. 60/318,386, attorney docket no. 25791.67.02, filed on 9/10/2001, (45) PCT application US

02/39425, filed on 12/10/02, attorney docket no. 25791.68.02, which claims priority from U.S. provisional patent application serial no. 60/343,674 , attorney docket no. 25791.68, filed on 12/27/2001, (46) U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (47) U.S. utility patent application serial no. 10/516,467, attorney docket no. 25791.70, filed on 12/10/01, which is a continuation application of U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (48) PCT application US 03/00609, filed on 1/9/03, attorney docket no. 25791.71.02, which claims priority from U.S. provisional patent application serial no. 60/357,372 , attorney docket no. 25791.71, filed on 2/15/02, (49) U.S. patent application serial no. 10/074,703, attorney docket no. 25791.74, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (50) U.S. patent application serial no. 10/074,244, attorney docket no. 25791.75, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (51) U.S. patent application serial no. 10/076,660, attorney docket no. 25791.76, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (52) U.S. patent application serial no. 10/076,661, attorney docket no. 25791.77, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (53) U.S. patent application serial no. 10/076,659, attorney docket no. 25791.78, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (54) U.S. patent application serial no. 10/078,928, attorney docket no. 25791.79, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no.

25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (55) U.S. patent application serial no. 10/078,922, attorney docket no. 25791.80, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (56) U.S. patent application serial no. 10/078,921, attorney docket no. 25791.81, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (57) U.S. patent application serial no. 10/261,928, attorney docket no. 25791.82, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (58) U.S. patent application serial no. 10/079,276 , attorney docket no. 25791.83, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (59) U.S. patent application serial no. 10/262,009, attorney docket no. 25791.84, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (60) U.S. patent application serial no. 10/092,481, attorney docket no. 25791.85, filed on 3/7/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (61) U.S. patent application serial no. 10/261,926, attorney docket no. 25791.86, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (62) PCT application US 02/36157, filed on 11/12/02, attorney docket no. 25791.87.02, which claims priority from U.S. provisional patent application serial no. 60/338,996, attorney docket no. 25791.87, filed on 11/12/01, (63) PCT application US 02/36267, filed on 11/12/02, attorney docket no. 25791.88.02, which claims priority from U.S. provisional patent application serial no. 60/339,013, attorney docket no. 25791.88, filed on 11/12/01, (64) PCT application US 03/11765, filed on 4/16/03, attorney docket no. 25791.89.02, which claims priority from U.S. provisional patent application serial no. 60/383,917, attorney docket no. 25791.89, filed on 5/29/02, (65) PCT application US 03/15020, filed on 5/12/03, attorney docket no. 25791.90.02, which claims priority from U.S.

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attorney docket no. 25791.69, filed on 10/3/2001, which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, and (121) U.S. utility patent application serial no. 10/418,688, attorney docket no. 25791.257, which was filed on 4/18/03, as a division of U.S. utility patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99.

[0071] It is understood that variations may be made in the foregoing without departing from the scope of the claims. For example, the teachings of the present illustrative embodiments may be used to provide a wellbore casing, a pipeline, or a structural support.
Furthermore, the elements and teachings of the various illustrative embodiments may be combined in whole or in part in some or all of the illustrative embodiments.

[0072] Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. Accordingly, it is appropriate that the appended claims be construed broadly.

Claims

1. A system for radially expanding and plastically deforming a tubular member within a preexisting structure, comprising:

means for support;

means for an internal passage coupled to and positioned within the support means;

pressure sensing means for sensing the operating pressure of an injected fluidic material;

means for radially expanding and plastically deforming the tubular member within the preexisting structure;

means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure; and

valve means releasably coupled to the support means said valve means controlling the flow of the fluidic material within the interior of the tubular member.

2. The system of claim 1, wherein the means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure comprises:

means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure before radially expanding and plastically deforming the tubular member within the preexisting structure.

3. The system of claim 1, wherein the means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure comprises:

means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure before or after radially expanding and plastically deforming the tubular member within the preexisting structure.

4. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

a support member;

a tubular stinger defining an internal passage coupled to and positioned within the support member;

an expansion device coupled to the support member comprising a rigid external expansion surface;

one or more pressure sensors coupled to the support member;

a plastically deformable expandable tubular member coupled to the rigid expansion surface of the expansion device comprising a first portion and a second

portion, wherein the inside diameter of the first portion is less than the inside diameter of the second portion; and

a movable valve releasably coupled to the support member for controlling the flow of fluidic materials through the interior of the expandable tubular member.

5. The apparatus of claim 4, wherein the pressure sensors comprise frangible elements.

6. The apparatus of claim 4, wherein the pressure sensors comprise valve elements for controlling the flow of fluidic materials within the interior of the expandable tubular member.

7. The apparatus of claim 6, wherein the support member defines one or more radial passages; and wherein the valve elements are positioned within corresponding radial passages.

8. The apparatus of claim 4, further comprising:

a tubular member movably coupled to the support member that defines an internal passage having a plug seat.

9. The apparatus of claim 8, wherein the movable valve is received within the internal passage of the tubular member.

10. The apparatus of claim 9, wherein the tubular member defines one or more radial passages; and wherein the movable valve defines one or more radial passages.

11. The apparatus of claim 8, wherein the tubular member sealingly engages an interior surface of the expandable tubular member.

12. The apparatus of claim 8, wherein the tubular member is coupled to the second portion of the expandable tubular member.

13. A method of radially expanding and plastically deforming a tubular member within a preexisting structure, comprising:

supporting the tubular member within the preexisting structure with a support member, wherein a tubular stinger defining an internal passage is coupled to and positioned within the tubular support member;

injecting fluidic material into the tubular member;

controlling the flow of the fluidic material using one or more movable valve elements that are coupled to an end of the tubular member;

sensing the operating pressure of the injected fluidic material;

if the sensed operating pressure of the injected fluidic material exceeds a predetermined value, then radially expanding and plastically deforming the tubular member within the preexisting structure; and

wherein one or more of the valve elements are releasably coupled to the support member.

14. The method of claim 13, wherein sensing the operating pressure of the injected fluidic material comprises sensing the operating pressure of the injected fluidic material using a sensor positioned within the expandable tubular member.

15. The method of claim 13, further comprising:

if the sensed operating pressure of the injected fluidic material exceeds a predetermined value, then permitting the injected fluidic material to pass through a flow passage within the expandable tubular member.

16. The method of claim 15, further comprising:

injecting a hardenable fluidic sealing material through and out of the interior of the expandable tubular member into an annulus between the expandable tubular member and the preexisting structure.

17. The method of claim 16, further comprising:

preventing the injected hardenable fluidic sealing material from passing though the flow passage.

18. The method of claim 13, further comprising:

injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure before radially expanding and plastically deforming the tubular member within the preexisting structure.

19. The method of claim 13, further comprising:

injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure after radially expanding and plastically deforming the tubular member within the preexisting structure.